Exhibit K2
Greater Sage-grouse
Habitat Equivalency Analysis Plan

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Final: Energy Gateway South Transmission Project Greater Sage-grouse Habitat Equivalency Analysis

Prepared by

Rocky Mountain Power – PacifiCorp

July 2015

FINAL: Energy Gateway South Transmission Project

Greater Sage-grouse Habitat Equivalency Analysis

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1.0 Project Overview

The Gateway South Transmission Line Project (GWS, Gateway South, or Project) is part of PacifiCorp's transmission expansion program, called Energy Gateway, which is intended to connect new and existing energy generation resources to customers throughout PacifiCorp's service territory. Energy Gateway is composed of several large-scale projects that will support increasing electric energy use and improve system reliability.

The Project is designed to provide 1,500 megawatts (MW) of new capacity needed to meet the current and forecasted needs of PacifiCorp's customers. These forecasts are based on PacifiCorp's Integrated Resource Plan as required to fulfill the regulatory requirements and guidelines established by the public utility commissions of the states served by PacifiCorp. The Integrated Resource Plan addresses the obligations of each company, pursuant to the Open Access Transmission Tariff, to plan for and to expand its transmission system in a non-discriminatory manner based on the needs of its native load and network customers.

Gateway South is independent of, and would be proposed regardless of, any particular new generation project. The transmission grid can be thought of in terms of hubs, spokes, and a backbone connecting the hubs. Each substation is a hub that receives or sends electricity along the spokes. For this system to work, a backbone of high-capacity transmission lines (including Gateway South) is needed to connect the hubs and transport the electricity from the source to the customer.

Gateway South will:

- provide long-term transmission capacity to move resources to growing load centers;
- connect Gateway West and Gateway Central, which will provide operational flexibility for the bulk electric network, increase reliability of the network, and support path ratings for each segment;
- improve capacity and reliability of other interconnected transmission lines associated with Energy Gateway;
- reduce transmission limitations on the existing system; and
- provide incremental transmission capacity planned at approximately 1,500 MW.

As proposed, the Project would be comprised of an extra high-voltage alternating current (AC) transmission line that would run between existing, planned, and proposed substations (Figure 1). The proposed single-circuit 500-kilovolt (kV) transmission line would be approximately 414 miles in length; the line would begin at the planned Aeolus Substation near Medicine Bow, Wyoming, connect to one separate proposed series compensation substation, and terminate at the existing Clover Substation near Mona, Utah. Two series compensation stations are planned between the Aeolus and Clover Substations, one in Colorado and one in Utah. Modifications at the existing Mona Substation are required to re-terminate existing lines to accommodate the nearby 500-kV termination at Clover Substation.

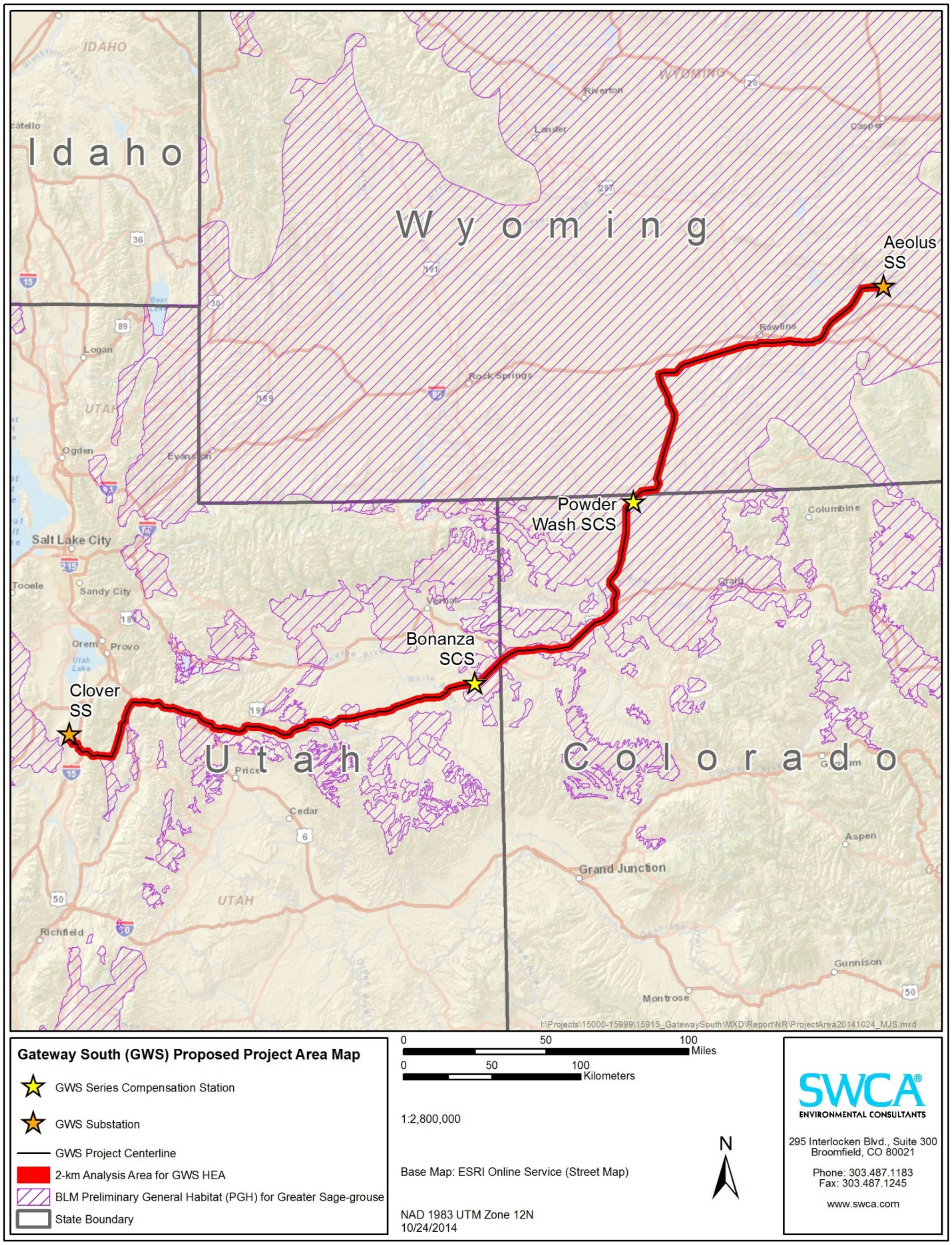


Figure 1. Project location relative to the BLM's PGH for sage-grouse, which encompasses the BLM's PPH for sage-grouse.

The Project will cross federal, state, and private lands along its route in Wyoming, Colorado, and Utah. The federal lands are primarily administered by the Bureau of Land Management (BLM). As such, PacifiCorp filed an application with the BLM to grant right-of-way (ROW) across public lands. The BLM, in compliance with the National Environmental Policy Act of 1969 (NEPA), is preparing an environmental impact statement (EIS) for Gateway South to inform its decision making on PacifiCorp's ROW grant application (BLM 2013).

The BLM, working in concert with the U.S. Fish and Wildlife Service (USFWS), developed a Framework for Sage-grouse Impacts Analysis (Framework for Impacts Analysis; January 2011), which was applied to the Energy Gateway West Project. The BLM and Rocky Mountain Power decided that the Framework for Impacts Analysis will be revised for application to Gateway South (meeting April 4, 2013). The Framework for Impacts Analysis addresses project-related impacts to greater sage-grouse (*Centrocercus urophasianus*) habitat that bear directly on listing factors considered by the USFWS when evaluating the need to provide full listing protection under the Endangered Species Act (ESA). According to the Framework for Impacts Analysis, mitigation is addressed after the NEPA-mandated impacts analysis has been conducted, resulting in an adequate understanding of impacts to sage-grouse populations and habitat, which is described in the EIS. The Framework for Impacts Analysis specifies the use of Habitat Equivalency Analysis (HEA), conducted by the project proponent, as a replicable method for determining mitigation that is scaled to project-related permanent and interim habitat losses.

The mitigation approach PacifiCorp will implement for the Project will follow the guidance provided by BLM Instruction Memorandums (IMs) IM 2013-142 (Interim Policy, Draft - Regional Mitigation Manual Section – 1794), 2012-043 (Greater Sage-Grouse Interim Management Policies and Procedures), and 2012-044 (BLM National Greater Sage-Grouse Land Use Planning Strategy), the Department of Interior Secretarial Order 3330 (Order 3330; Improving Mitigation Policies and Practices of the Department of the Interior), and the USFWS Greater Sage-grouse Range-Wide Mitigation Framework (Range-Wide Mitigation Framework; USFWS 2014). Collectively, these provide guidance for greater sage-grouse habitat management and mitigation for pending transmission ROWs in Preliminary Priority Habitat (PPH) and Preliminary General Habitat (PGH). These policies state that transmission ROWs having disturbances greater than 1 linear mile or 2 acres require cooperation between the BLM, project proponents, and other appropriate agencies to develop and consider implementation of appropriate regional mitigation to avoid or minimize habitat and population-level effects to greater sage-grouse.

Under these policies, offsite and onsite mitigation can include in-kind or out-of-kind mitigation. In-kind is defined as the replacement or substitution of resources that are of the same type and kind of those being impacted. Out-of-kind is defined as replacement or substitutions of resources that while related are of equal or greater overall value to public lands. In addition, IM 2013-142 also identifies that the BLM may accept monetary contributions, how they may be used, and that mitigation may be conducted on non-federal lands.

In compliance with IM 2012-43, IM 2013-142, IM 2012-044, Order 3330, the Range-Wide Mitigation Framework, and the Framework for Impacts Analysis, PacifiCorp has completed an HEA to determine the amount of compensatory mitigation necessary to offset potential direct impacts and select indirect impacts to greater sage-grouse resulting from the construction, operation, and maintenance of the Project in all known sage-grouse habitat in Wyoming, Colorado, and Utah that are intersected by the agency preferred alternative selected by the BLM through the NEPA process. This HEA is one part of a larger mitigation plan being prepared by PacifiCorp. The mitigation plan will use the HEA to quantify the compensatory mitigation obligation for direct impacts and select indirect impacts. The mitigation plan will additionally include compensatory mitigation for indirect impacts not modeled in the HEA.

The HEA produced an estimate of the permanent and interim potential loss of greater sage-grouse habitat services as a result of vegetation loss, noise, and human presence anticipated with Project construction and operation. The HEA also modeled mitigation measures that may be implemented to offset the potential lost habitat services from modeled project effects. Refer to Pacificorp's sage-grouse mitigation plan (in development) for specifics on mitigation projects and to review PacifiCorp's approach to mitigating project effects characterized by the Framework for Impacts Analysis that could not be modeled in the HEA.

The following sections provide overviews of HEA, the HEA process for the Project, the methods used for the HEA, habitat service losses estimated by the HEA, and potential types of mitigation measures that could be used to compensate for habitat loss. Detailed methods excerpt from the Project's HEA Plan are provided in the appendices to this report.

2.0 Overview of Habitat Equivalency Analysis

A HEA is a science-based, peer-reviewed method of quantifying interim and permanent habitat injuries, measured as a loss of habitat services from pre-disturbance conditions, and scaling compensatory habitat requirements to those injuries (King 1997; Dunford et al. 2004; Allen et al. 2005; Kohler and Dodge 2006; National Oceanic and Atmospheric Administration [NOAA] 2006, 2009). Habitat services include those ecosystem features (i.e., physical site-specific characteristics of an ecosystem) and ecosystem functions (i.e., biophysical processes that occur within an ecosystem) that support wildlife and human populations (King 1997).

Habitat services are generally quantified using a metric that represents the functionality or quality of habitat (i.e., the ability of that habitat to provide wildlife "services" such as nest sites, forage, cover from predators, etc.). When wildlife habitat is the primary service of interest, areas with the highest habitat service levels are those areas with highest habitat quality. Interim (or short-term) habitat injuries are those services that are absent during certain phases of the project that would have been available if that disturbance had not occurred (e.g., temporary vegetation losses, temporary soil partitioning, temporary displacement of wildlife populations). Permanent habitat injuries are those habitat injuries remaining after project completion and interim reclamation and recovery are complete (e.g., permanent vegetation loss, permanent loss of wildlife or fisheries populations, irrecoverable impacts to soils or water as a result of contamination).

HEA uses a service-to-service approach to scaling. HEA does not assume a one-to-one trade-off in resources (e.g., number of acres). Rather, HEA balances the number of services lost with those that are gained as a result of conservation activities (NOAA 2006). For example, 1 acre of land with a diverse vegetative structure and abundant tree canopy can support higher numbers of nesting songbirds (an example of a habitat service of interest) than 1 acre of land with few trees and little vegetative diversity. The two land parcels, although equal in size, provide unequal habitat services.

2.1 What Does Habitat Equivalency Analysis Do?

HEA is an economics model that:

- quantifies current habitat services provided in a project area or landscape (commonly referred to as the baseline habitat service level);
- quantifies the interim and permanent injuries to the baseline habitat service level; and
- determines appropriately scaled restoration and conservation activities to offset habitat services lost as a result of project impacts.

2.1.1 Benefits of Habitat Equivalency Analysis

The following are benefits of HEA.

- High credibility – the approach has been evaluated and documented in scientific peer-reviewed literature and has held up in numerous court cases.
- Analyses are quantitative rather than qualitative in nature.
- Equations are straightforward, but have enough input variables to allow flexibility in project design.
- Provides a replicable method for negotiation of mitigation ratios, acceptable compensatory restoration, and/or fines.
- Valuable planning tool; can be used to evaluate the cost of multiple compensatory mitigation measures.
- Applicable to any ecosystem type where an appropriate habitat services metric can be defined.
- Currently the most commonly used method by natural resource trustees to assess damages to ecosystems.
- Used by federal regulatory agencies, such as the USFWS, NOAA, BLM, Environmental Protection Agency, Department of Interior, and U.S. Army Corps of Engineers.

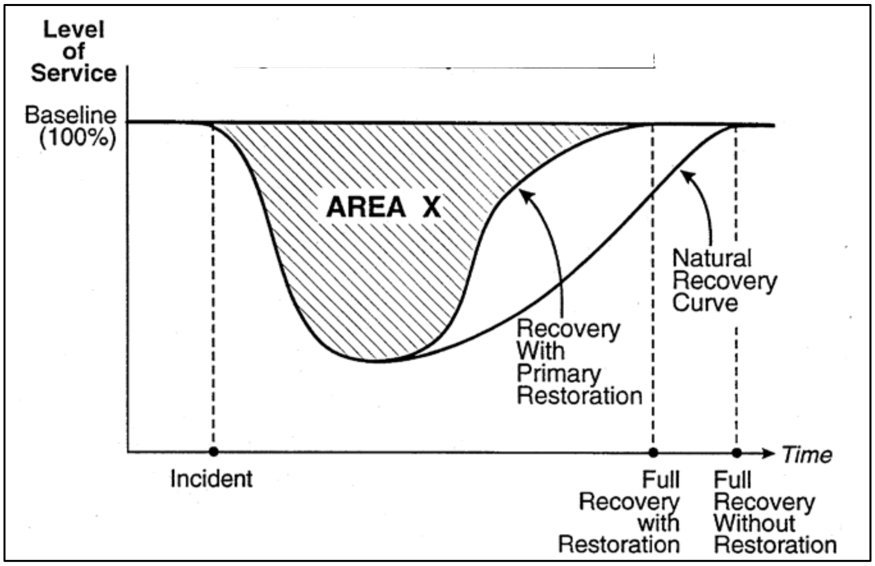
2.1.2 When Habitat Equivalency Analysis Should Be Used

Based on Chapman (2004), HEA is an appropriate tool for scaling mitigation when:

- habitat services can be defined or modeled;
- quantification of project impacts is possible;
- replacement of services lost is feasible; and
- conservation methods are sufficiently known.

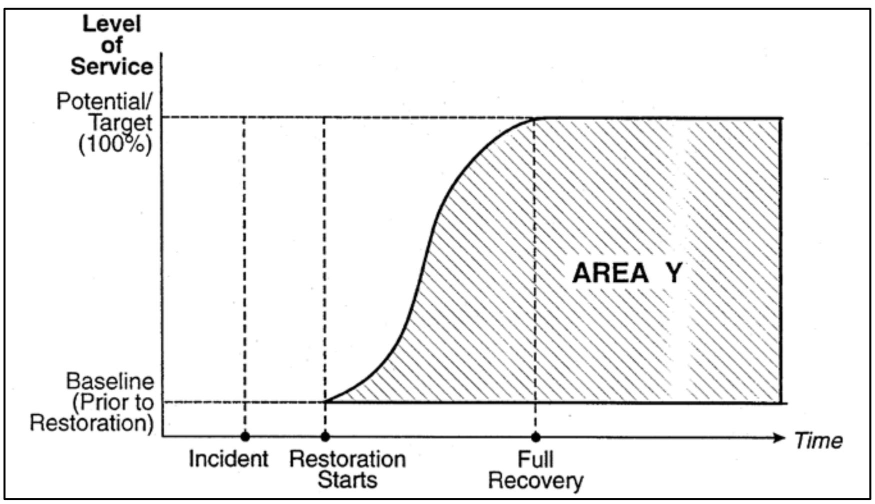
2.2 Compensation Components

Compensation for impacts includes two components: 1) recovery of the injured area (primary restoration) (Figure 2); and 2) compensation for the interim loss of habitat services occurring prior to full recovery (compensatory restoration) (Figure 3).



Area X represents the services lost at an injury site with Primary Restoration expressed as percent of baseline (King 1997).

Figure 2. Changes in habitat service level compared to the baseline service level during construction and restoration.



Area Y represents the services gained at the compensatory restoration site expressed as percent of potential/target level less baseline (pre-restoration) percent (King 1997).

Figure 3. Changes in habitat service level with compensatory restoration.

HEA quantifies the habitat services lost during the lifetime of a project compared to baseline (Area X in Figure 2) and scales the compensatory project (mitigation project) so that it provides services that are equal to that loss (Area Y in Figure 3). Baseline refers to the condition of the resources and quantity of habitat services that would have existed had the disturbance not occurred. The quantity of services lost (Area X) depends on the extent of the injury and the time required for restoration; actions taken to accelerate the rate of primary restoration would decrease the interim loss of habitat services, requiring less compensatory restoration. In some cases, full restoration of the lost services may not be feasible, in which case the area required for compensation (Area Y) would be larger. Compensatory restoration may occur off-site (e.g., the purchase of additional habitat), or on-site through habitat improvements that increase habitat services above baseline.

2.3 Measuring Habitat Services (Ecological Economics)

Quantifying the services provided by an ecosystem is a complex task. This complexity can be reduced through the use of an attribute, or metric, that provides a measure of the services of interest. The metric must be able to capture the relative differences in the quality and quantity of services being provided before and after restoration and between primary and compensatory sites (NOAA 2009).

Measurements of habitat services over the lifetime and area of a project are used in the HEA. These measurements have three components: land area, service level, and time. The relative service level can be quantified using a metric that measures or scores one or more key habitat elements for a species or wildlife community of interest (e.g., vegetation stem density, vegetation type, nest density, percentage of canopy cover, proximity to critical habitat, etc.). Habitat services are commonly expressed in service-acres (1 year) or service-acre-years (multiple years).

3.0 Overview of the Habitat Equivalency Analysis Process for the Project

Completion of the HEA process for the Project agency preferred alternative required close coordination with the BLM, other appropriate agencies, and stakeholders (the HEA Technical Advisory Team, hereafter). Such coordination ensures that the best available scientific data were used, the habitat service metric was appropriate for resources in the Project area, the results of the HEA are understood, and the compensation offsets the interim and permanent loss of habitat services modeled. The following steps have been completed as part of the development of the HEA for the Project.

1. **Establishing baseline habitat services prior to disturbance.**

   PacifiCorp worked closely with the HEA Technical Advisory Team to finalize a habitat services metric that quantified the baseline greater sage-grouse habitat services available prior to Project construction. Appendix A provides information related to the development of the habitat services metric that served as the basis for quantifying baseline habitat services and determining Project impacts and appropriate mitigation. Appendix B presents information related to how this metric was applied to establish baseline habitat services for the Project area. Development of the baseline habitat service metric presented in Appendix A considered the best available scientific information regarding greater sage-grouse habitat and average response to disturbance. The same metric was applied to all states, which assumes that high value habitat looks the same and has the same value to sage-grouse along the entire length of the project. Insufficient baseline grouse population data were available to model more nuanced effects to the populations affected.

2. **Quantifying the permanent and interim losses to the baseline service level that result from the Project disturbance.**

   Permanent and interim losses of habitat services anticipated with the construction and operation of the Project were quantified as described in Appendix C. These are the habitat losses (measured in discounted service-acre-years) that remain after accounting for reclamation efforts and vegetation recovery in the ROW over the life of the Project, and they will provide the basis for assessing the adequacy of mitigation proffered by PacifiCorp for Gateway South.

3. **Identifying appropriate mitigation measures that may be used to compensate for lost services.**

   PacifiCorp worked with the HEA Technical Advisory Team to identify mitigation measures that may be used to compensate for the permanent and interim losses of habitat services. All mitigation measures would be subject to appropriate land management agency or landowner approval, permits, and planning. Appendix D describes the methods that were used to quantify habitat service gains resulting from mitigation measures.

   In the HEA process, the benefits of mitigation measures must be quantifiable using the habitat services metric. Additional mitigation measures with benefits that cannot be quantified in the HEA (e.g., brood-rearing habitat improvement and understory improvement measures) will be considered separately in PacifiCorp's Mitigation Plan for Gateway South and their compensatory value determined in coordination with the lead agencies and other stakeholders.

4. **Quantifying the amount of mitigation necessary to compensate for the losses to baseline services that remain after the Project implementation.**

   The average habitat service gain and cost per service returned were quantified for each of the final mitigation measures identified by PacifiCorp, lead agencies, and involved stakeholders. The resulting values will be balanced with the services lost to determine the compensatory mitigation appropriate to offset the permanent and interim loss of greater sage-grouse habitat services resulting from development of the Project. This balancing will occur in PacifiCorp's mitigation plan for Gateway West with a proposed mitigation project mixture. PacifiCorp's mitigation plan for Gateway South that documents the scaled compensatory mitigation will be provided to BLM as a voluntary applicant-committed mitigation measure for greater sage-grouse habitat.

4.0 USFWS Conservation Framework for Greater Sage-grouse

In February 2013, the USFWS issued a Conservation Objectives Report (COR) (USFWS 2013) that details the finding of a Conservation Objectives Team (COT) that was convened and asked to develop and recommend the degree and types of threats that would need to be reduced or eliminated in order to conserve the sage-grouse from being in danger of extinction and to prevent the likeliness of the sage-grouse becoming in danger of extinction in the foreseeable future. Part of the recommendation by in the COR was to achieve the objectives set forth in the Western Association of Fish and Wildlife Agencies' (WAFWA) Greater Sage-grouse Comprehensive Conservation Strategy (Stiver et al. 2006), the main goal of this being to reverse the declining population trends and obtain either a neutral or increasing population trend.

In order to meet the objectives of the COR, conservation frameworks were developed to achieve the long-term conservation of the sage-grouse. This document describes how the long-term conservation of sage-grouse and their habitats—sagebrush shrub and native perennial grass and forb communities—should be achieved by maintaining viable, connected, and well-distributed populations and habitats across their habitat range, through threat elimination, conservation of key habitats, and restoration activities. The conservation framework of the COR consists of the following.

1. Defining general conservation goals.
2. Developing specific conservation objectives and measures.
    a. Identifying priority areas for conservation.
    b. Identifying sage-grouse population threats.

Three parameters—population representation, habitat representation, and redundancy—were used as guiding concepts in developing the conservation goal, priority areas for conservation, conservation objectives, and measures. This conservation framework was also used in the development of the HEA framework, which is discussed in Section 5.

4.1 General Conservation Objectives

The following section lists the general conservation objectives that were developed by the COT.

1. **Stop population declines and habitat loss.**

   Eliminating activities known to negatively impact sage-grouse and their habitats or redesigning these activities to achieve the same goal and management must continue to effectively conserve all current priority areas for conservation (PACs).

2. **Implement targeted habitat management and restoration for populations that are essential to maintain range-wide redundancy and representation.**

   Use pro-active management of non-anthropogenic threats (e.g., strategic placement of firefighting resources) and restoration efforts. The effectiveness of restoration activities must be demonstrated prior to receiving any credit for mitigation losses. Effective habitat conservation and, as appropriate, restoration activities, should be implemented immediately. Development and implementation of monitoring plans for these activities is an essential component of these efforts. In addition, some areas are not included as PACs but may still have great potential for providing important habitat if active habitat management is implemented. Successful habitat management efforts could increase connectivity between PACs and will enhance management flexibility in conserving the species.

3. **Develop and implement state and federal sage-grouse conservation strategies and associated incentive-based conservation actions and regulatory mechanisms.**

   Stakeholders should work together to develop a plan, including any necessary regulatory or legal tools (or use an existing plan, if appropriate) that includes clear mechanisms for addressing the threats to sage-grouse within PACs. Successful implementation of regulatory and incentive-based mechanisms to conserve sage-grouse requires that all stakeholders participate in conservation, regardless of the size, type, ownership, or location of the threat impact. Conservation strategies should consider criteria identified in the USFWS/NOAA Fisheries *Policy for Evaluation of Conservation Efforts When Making Listing Decisions*. Regulatory mechanisms must be completed and implemented and incentive-based conservation actions negotiated as quickly as possible… All regulatory and incentive-based mechanisms should have a monitoring plan that will provide scientifically defensible data regarding their effectiveness.

4. **Develop and implement proactive, voluntary conservation actions.**

   Proactive, incentive-based, voluntary conservation actions (e.g., Candidate Conservation Agreements with Assurances, Natural Resources Conservation Service programs) should be developed and/or implemented by interested stakeholders and closely coordinated across the range of the species to ensure they are complimentary and address sage-grouse conservation needs and threats. These efforts need to receive full funding.

5. **Develop and implement monitoring plans to track the success of state and federal conservation strategies and voluntary conservation actions.**

   A robust range-wide monitoring program must be developed and implemented for sage-grouse conservation plans. Adequate funding must be secured for development, implementation, and enforcement of regulatory and incentive-based mechanisms, other conservation strategies, and monitoring programs. A monitoring program is necessary to track the success of conservation plans and proactive conservation activities. Without this information, the actual benefit of conservation activities cannot be measured and there is no capacity to adapt if current management actions are determined to be ineffective. New or adapted management actions must be developed and implemented if the monitoring determines that current management actions are ineffective.

6. **Prioritize, fund, and implement research to address existing uncertainties.**

   Increased funding and support for key research projects that will address uncertainties associated with sage-grouse and sagebrush habitat management is essential. Effective amelioration of threats can only be accomplished if the mechanisms by which the impacts of the threats that are imposed are understood.

Specific conservation objectives and measures from the COR are provided in Appendix F.

4.2 Consistency of the HEA with COR Conservation Objectives

PacifiCorp worked with lead agencies and involved stakeholders to identify mitigation measures that further the objectives defined in the COR for modeling in this HEA. Descriptions of how the modeled mitigation measures fit into the COR objectives are provided in Section 5.3. Development of the HEA itself is also consistent with the recommendation by the COR that habitat function lost from the placement of infrastructure should be replaced. The objective of the HEA is to measure the habitat services (habitat function) lost so that the mitigation plan can identify projects to replace them. The relative value of the project impacts and benefits of mitigation projects were assumed to be the same across all states affected by the Project in the HEA.

5.0 Overview of the Habitat Equivalency Analysis Methods Used

The following sections provide an overview of methods used to develop the HEA models that were applied to assess the loss of greater sage-grouse habitat services associated with the Project development and the benefits of various conservation project types that may be proposed for mitigation.

5.1 Development of Habitat Service Metric

To quantify the habitat services (e.g., greater sage-grouse habitat functionality) provided by an ecosystem, a habitat service metric was developed that scores key habitat elements for the species. Scoring habitat services is a critical step in the HEA process because it provides a way to quantitatively measure the quality of specific habitat functions in a specific area. The habitat metrics used in the HEA had to be able to capture the relative differences in the quantity of services provided before and after construction and conservation-focused activities. Habitat services often have three components—land area, service level, and time—and are commonly expressed in service-acres (1 year) or service-acre-years (service-acres summed over multiple years).

The greater sage-grouse habitat services metric for the Project was developed collaboratively by the HEA Technical Advisory Team. The focus of the metric was to capture changes in greater sage-grouse habitat services over time with vegetation removal and recovery. Using this approach, lost habitat services (decreases in habitat quality) must be replaced with like services. The HEA does not assume a one-to-one trade-off in resources (e.g., number of acres of greater sage-grouse habitat affected), but instead determines compensation based on the habitat services those acres provide (e.g., development in high-quality greater sage-grouse habitat would have higher compensation levels than development in lower-quality habitat that provides fewer services).

The habitat service metric developed for the Project included variables identified by the peer-reviewed literature as having influence on the quality of greater sage-grouse habitat, including dominant vegetative components and anthropogenic influences (Table 1). The variables included were limited to those for which reliable and consistent data were available across the Project area. For each of the variables, a habitat service score ranging from 0 to 3 (zero to high services) was assigned for categories like those defined in the *Sage-grouse Habitat Assessment Framework* multi-scale habitat assessment tool (Stiver et al. 2010). Categorical variables were more appropriate than continuous variables due to the resolution of the remotely sensed vegetation data available for the length of the Project. The break points between service scores for a variable (e.g., the measurement on the border between scores 1 and 2 for a variable) were primarily based on information contained in the literature regarding greater sage-grouse habitat use and selection. When literature did not allow for direct quantification of the HEA scores, professional judgments of the HEA Technical Advisory Team informed by the available peer-reviewed literature were used. When measurements for a particular variable matched conditions described as being optimal in the literature, that variable was given a service score of 3.

The metric for greater sage-grouse habitat services used in this HEA was an additive model (Table 1). Each cell in the analysis area is scored separately by summing the scores of Variables 01 through 08 and all variables are weighted evenly. Once summed, a score adjustment is made for the presence of fences posing a high collision risk to greater sage-grouse during the lekking season. The score was adjusted by multiplying it by a factor that reduces the overall summed score where high risk fences are present. For example, if a cell has a summed score of 20, but occurs where a fence has a predicted sage-grouse collision rate of 0.3 bird, the summed score of 20 would be multiplied by 0.75 (the assigned adjustment factor for a collision rate of 0.3 bird) producing a final additive score for that cell of 15. Each of the eight variables and the fence collision score adjustment are described in detail in Appendix A.

There are several types of lands that are excluded from the HEA, meaning that no matter the additive score in that cell, if it is part of an excluded land then it receives a score of zero overall. The excluded land are land cover types that are typically avoided by the sage-grouse. These avoided lands include all forest types, urban areas, open water, some introduced vegetation types, roadways, well pads, mine footprints, areas <100 meters (m) from roadways with >6,000 annual average daily traffic (AADT) and <25 m of paved roads with <6,000 AADT, and heavily traveled gravel roads (multiple sources per USFWS listing decision in *Federal Register*; Johnson et al. 2011). The specific national Gap Analysis Program (GAP) vegetation classifications that were included in these avoided land cover types (forests, urban areas, etc.) are listed in Appendix E.

The HEA metric was used to score habitat service level for all areas on and within 2 kilometers (km) of the Project centerline (Assessment Area). None of the habitat service losses modeled (vegetation loss, noise, and human presence) extended outside the Assessment Area. Finally, the Assessment Area was clipped to the BLM’s greater sage-grouse PGH. The PGH layer used in the analysis encompassed the BLM’s greater sage-grouse PPH, so the Assessment Area only included those areas that are recognized as known sage-grouse habitats.

Table 1. Anthropogenic and Habitat Variables Used as a Metric of Greater Sage-grouse Habitat Services

Variable Number	Variables Description	HEA Score Criteria 3	2	1	0	Primary Citations^
VAR01	Distance to high-traffic (>6,000 AADT) road, such as an interstate, federal, or state highway (meters)	>1,000	650–1,000	100–650	<100*	Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR02	Distance to low-traffic (<6,000 AADT) paved roads, heavily travelled gravel roads, well pads, mine footprints, transmission substations (meters)	>200	50–200	25–50	<25*	Connelly et al. (2004); Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR03	Percent slope	<10	10–30	30–40	>40	Beck (1977); Lincoln County Sage Grouse Technical Review Team (2004)
VAR04	Distance to occupied lek† (kilometers)	0–6.4	6.4–8.5	>8.5	N/A	Cagney et al. (2009); Connelly et al. (2000); Connelly et al. (2011); Holloran and Anderson (2005)
VAR05	Sagebrush abundance index (% of vegetation that is sagebrush within a 1-square-kilometer moving window)	50–95	30–50 or >95	10–30	0–10	Carpenter et al. (2010); Walker et al. (2007); Aldridge and Boyce (2007); Aldridge et al. (2008); Wisdom et al. (2011)
VAR06	Percent sagebrush canopy cover	15–35	5–15 or >35	1–5	<1	Cagney et al. (2009); Connelly et al. (2000); Stiver et al. (2010)
VAR07	Sagebrush canopy height (centimeters)	30–80	20 to <30 or >80	5–20	<5	Crawford et al. (2004); Connelly et al. (2000); Stiver et al. (2010)
VAR08	Distance of habitat to sage or shrub dominant (meters)	<90	90–275	275–1,000	>1,000	BLM et al. (2000); Connelly et al. (2000); Lincoln County Sage Grouse Technical Review Team (2004)

* Lands less than 100 meters from a high traffic road and less than 25 meters from a low traffic paved road or high traffic gravel road were given a total metric score of 0 (provides no habitat services), not just a score of 0 for these individual variables. This is referred to as the road "width" in the direct impacts, although it is larger than the actual physical width of the road.

^ Greater sage-grouse habitat suitability publications vary in their descriptions of the baseline environmental conditions affecting a particular study site. Even studies within a single state may describe different suitable habitat conditions depending on elevation, precipitation zone, and other geographic or climatic factors affecting each study site. The habitat metric relied on generalizations presented in BLM et al. (2000), Cagney et al. (2009), Connelly et al. (2011), Connelly et al. (2000), Stiver et al. (2010), and other summary publications. Specific citations are given to support these generalizations when applicable. The same metric of habitat services was applied to the entire Project area.

† Leks were classified as occupied if their 10-year attendance average was greater than 0.

AADT = annual average daily traffic

5.2 Quantification of Habitat Service Losses

The following sections describe the losses of habitat services that would likely occur as a result of the Project construction and operation. These changes in the habitat service level were simulated in a geographic information systems (GIS) platform to produce data inputs for the HEA.

The HEA model calculates the present value of future changes to the baseline habitat service level with time caused by losses of habitat services with Project development and gains of habitat services with mitigation projects. Economists call this process *discounting* and it is a standard part of the HEA model. Discounting converts services being provided in different time periods into current time period equivalents (Allen et al. 2005). Discounting results in a gradual increase in the service-acres provided by injured habitats over time (the habitat service loss is discounted), and the same rate of decrease in service-acres gained by habitat conservation over time (the habitat service gain is discounted). Consequently, credit for mitigation in the form of habitat conservation is greater when implemented early in the lifetime of the Project than when implemented late in the lifetime of the Project. This encourages early mitigation to offset habitat service losses to ensure that long-term adverse effects to the resource are minimal.

Ideally, the baseline habitat service level would account for all habitat service losses associated with existing environmental disturbances. This was done to the extent possible with the existing data for the Assessment Area. In some cases, existing habitat disturbances were not mapped in the baseline service level because they were not detected by the chosen habitat services metric or because the data were unavailable for use in the baseline analysis. Omission of these disturbances is a conservative approach to the analysis of the Project-related habitat service losses. When baseline disturbances are omitted, the analysis assumes that the habitats affected by the Project are of higher-quality than they actually are and thus require a greater amount of mitigation to offset the Project-related habitat service losses.

The habitat services provided by the Assessment Area were calculated at Project milestones that reflected varying levels of disturbance. The Project milestones modeled with GIS data for the HEA are listed below. Snapshots of the changing habitat services over time were modeled using GIS-based tools for each of the milestones identified above for incorporation into the HEA. The HEA calculated the total interim and permanent habitat injuries that can be quantified by the metrics used. As there may be additional Project impacts that were not modeled, such as unknown or unquantified indirect effects, the total anticipated habitat injury may be greater by an unknown amount. The potential for habitat injuries not quantified by the HEA is addressed separately by the mitigation plan. Specifics of the GIS and HEA methods are provided in Appendix C.

The HEA Technical Advisory Team decided that habitat services would be scored using the same habitat service metric in all states. Likewise, the habitat service losses modeled for specific Project impact types were the same in all states. The value of the habitat services present at baseline and the value of the habitat services lost due to the Project does not reflect the number of birds using that habitat (except measured as proximity to a lek). In some cases, the habitat may be overvalued or undervalued with regard to the population's relative management value as a result.

The habitat service losses were calculated based on the project layout and project construction schedule in each State. The footprint of the Project was provided electronically by PacifiCorp (dated 10/13/2014). The footprint files specified the anticipated locations of and direct disturbance associated with new and existing access roads, transmission towers, pulling/tensioning areas, two series compensation stations, and helicopter yards. These locations are approximate and have not yet been sited to take advantage of existing roads. Thus, all access roads are assumed by this analysis to produce a new disturbance, which should produce an overestimate of the actual impact. Again, this is consistent with a conservative approach to mitigation planning.

The planned Aeolus substation is being mitigated by the Gateway West Transmission Line Mitigation Plan and the Clover substation is already operational, so these substations are not modeled as new impacts but are characterized as baseline habitat disturbances.

The construction schedule provided by PacifiCorp (dated 9/15/2014) illustrates the Project being divided into 7 spreads, with construction staggered among spreads over a period of 146 weeks. Construction within a single spread is complete in 83-150 weeks (1.6 to 2.9 years). Construction is planned to take longer in the Utah spreads (mean 2.5 years, range 2.1 to 2.9 years) than in Wyoming (mean 1.7 years, range 1.6 to 1.9 years) or Colorado (mean 2.0 years, range 1.8 to 2.1). Accordingly, 3 years of construction was modeled for Utah, and 2 years of construction was modeled for Wyoming and Colorado. Direct and indirect disturbances modeled are described by milestone and project year in Tables 2 and 3, respectively.

Table 2. Direct Disturbance Levels Modeled by Project Year and Disturbance Type

Project Milestones	Project Year Applied in Wyoming and Colorado	Project Year Applied in Utah	Percent Baseline Services Present at Each Milestone by Direct Disturbance Type		
			Series Compensation Stations	Transmission Towers* (360 feet^2 of the pad†)	New and Existing Access Roads, Helicopter Pads, Transmission Towers (remainder of pad), Pulling/Tensioning Site, and Elsewhere‡
Baseline	0	0	100%	100%	100%
Construction	1, 2	1, 2, 3	0%	0%	0%
Restoration	3	4	0%	0%	0%
Recovery 1	4	5	0%	0%	100% of agricultural and wetland 20% of grassland and riparian 5% of shrub 1% of sagebrush
Recovery 2	8	9	0%	0%	100% of agricultural and wetland 100% of grassland and riparian 25% of shrub 5% of sagebrush
Recovery 3	23	24	0%	0%	100% of agricultural and wetland 100% of grassland and riparian 100% of shrub 20% of sagebrush
Recovery 4	103	104	0%	0%	100% of agricultural and wetland 100% of grassland and riparian 100% of shrub 100% of sagebrush

* The self-supporting steel lattice tower is assumed for this analysis.
† Tower pad in this table refers to the permanent tower footprint.
‡ Elsewhere refers to construction roads that were reduced to two-track roads, or any areas where vegetation was cleared for Project construction that were subsequently revegetated during restoration (e.g., staging areas).

Table 3. Indirect Disturbance Levels Modeled by Project Year and Disturbance Type

Project Milestones	Project Year Applied in Wyoming and Colorado	Project Year Applied in Utah	Indirect Disturbance Buffers* Applied by Disturbance Type: Series Compensation Stations	Indirect Disturbance Buffers* Applied by Disturbance Type: Transmission Towers* (360 feet^2 of the pad)	Indirect Disturbance Buffers* Applied by Disturbance Type: New and Existing Access Roads, Helicopter Pads, Transmission Towers (remainder of pad), and Pulling/Tensioning Site
Baseline	0	0	None	None	None
Construction	1, 2	1, 2, 3	Secondary Road*	Secondary Road	Secondary Road
Restoration	3	4	Secondary Road	None	None
Recovery 1	4	5	Secondary Road	None	None
Recovery 2	8	9	Secondary Road	None	None
Recovery 3	23	24	Secondary Road	None	None
Recovery 4	103	104	Secondary Road	None	None

* "Secondary Road" indicates that the footprint of the disturbance was classified as having the same indirect disturbance as a secondary road in the GIS model (Variable 2 in Table 1) and the scores of the surrounding vegetation decreased as defined by the habitat services metric.

5.2.1 Baseline

The baseline milestone quantifies habitat services available to greater sage-grouse before the proposed project disturbance. The calculation of the baseline is described in Appendix B. Habitat services were scored per the habitat service metric without consideration for state, population size, or the relative management value of the population. Habitat with the same physical attributes received the same score regardless of its location or conservation designation.

The inclusion or exclusion of existing impacts in the baseline habitat model is consistent with the impacts modeled for the Project—it includes direct impacts and some indirect impacts, but not all potential indirect impacts. Some existing disturbances are accounted for (e.g., oil and gas wells, paved roads, urban areas) and others are not (e.g., existing transmission lines, low-traffic gravel roads). Inclusion or exclusion of disturbances in the baseline model is dependent on how that disturbance was characterized in the GAP vegetation layers and scored by the habitat service metric. Exclusion of existing impacts inflates the baseline habitat service value, requiring a greater level of mitigation to offset; it is a more conservative approach than modeling all existing impacts. Figures 4 through 8 show the baseline services for the Gateway South HEA assessment area (i.e., only those areas within BLM PGH areas and within a 2-km buffer of the Project centerline). In these figures, there is a gradient of color from red through yellow to blue. Red represents a high relative habitat quality (high HEA score) and blue represents a low relative habitat quality (low HEA score), with the darker shades depicting the extremes.

5.2.2 Construction

The construction milestone quantifies habitat services available to greater sage-grouse during the construction and the operation of the Bonanza SCS and Powder Wash SCS proposed as part of the Project and the construction of the transmission line and electrode grid. Magnitude of the loss of habitat services during construction is dependent on proximity to the Project and the amount of new surface disturbance.

Direct Disturbance

During the three construction years, direct disturbance was defined as the loss of all habitat services within the entire construction footprint for the segment modeled (see Table 2). All access roads were assumed to have a width of 50 m (the centerline buffered to 25 m per Variable 02 in the metric) and were modeled as secondary roads (Variable 02 in Table 1). The actual surface road widths will be narrower than the modeled road width; this width reflects the area unusable by sage-grouse during construction per the literature (see Appendix A, Section A.1.1). Although the Project will be sited to align with existing roads wherever possible, this siting process had not been completed at the time of the analysis. Access road impacts during construction will be overestimated as a result of this assumption, resulting in a greater mitigation burden. Additionally, the model did not capture seasonal restrictions on the Project construction required by the BLM, which may have resulted in high estimates of service losses in the three construction years.

Indirect Disturbance

In addition to the actual surface disturbance, indirect disturbance buffers were applied to reduce habitat services around the Project footprint during active construction (see Table 3). Within these buffers (>200 m, 50–200 m, 25–50 m, or <25 m), the habitat services were scored by the metric as if they were in the same as Variable 02 to account for the disturbance associated with noise and human presence (Appendix C). The buffers were applied to the centerline of roads or to the perimeter of other disturbance types.

There are potentially additional indirect impacts of unknown magnitude and extent that were not included in the model. These will be addressed separately by PacifiCorp's mitigation plan for the Project.

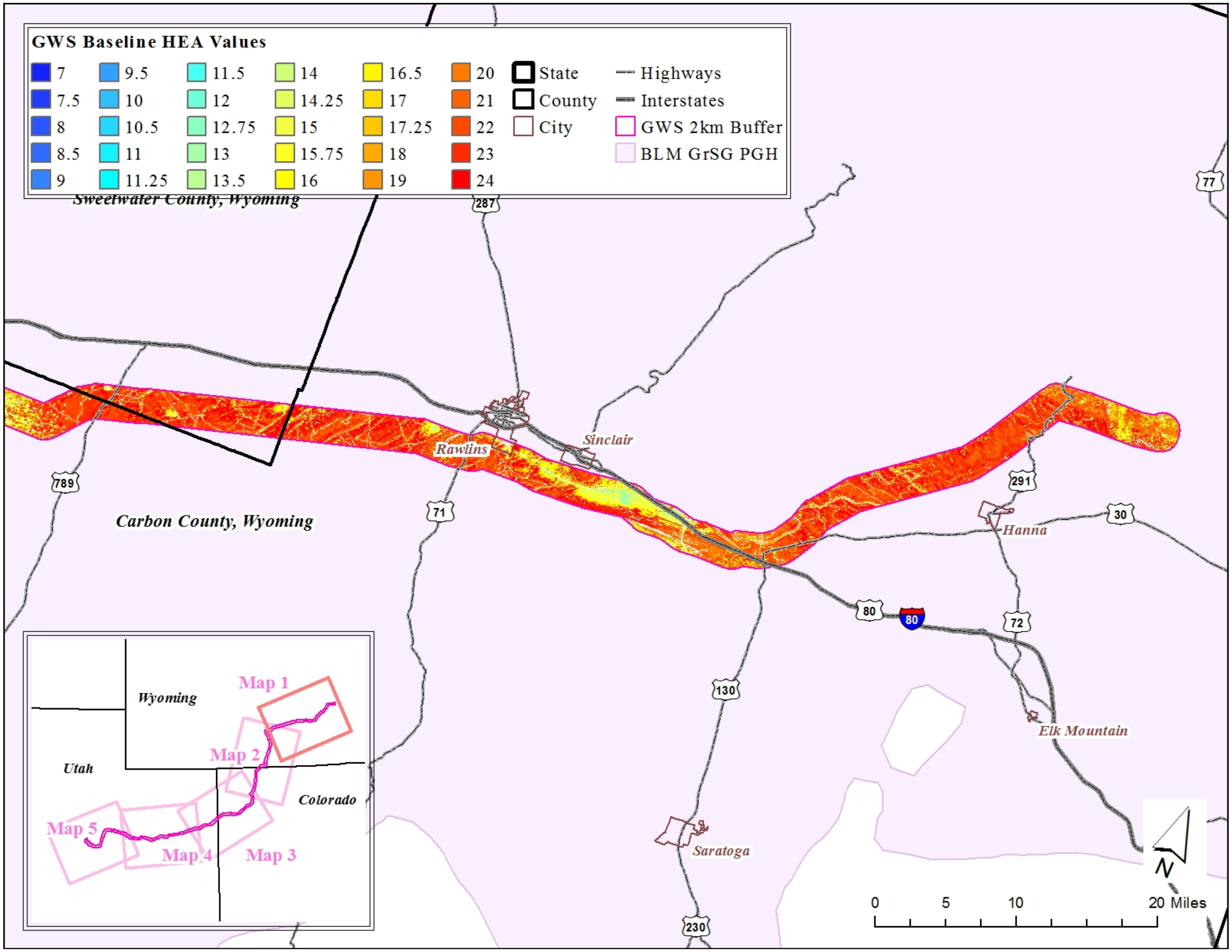


Figure 4. GWS baseline HEA values (map 1 of 5).

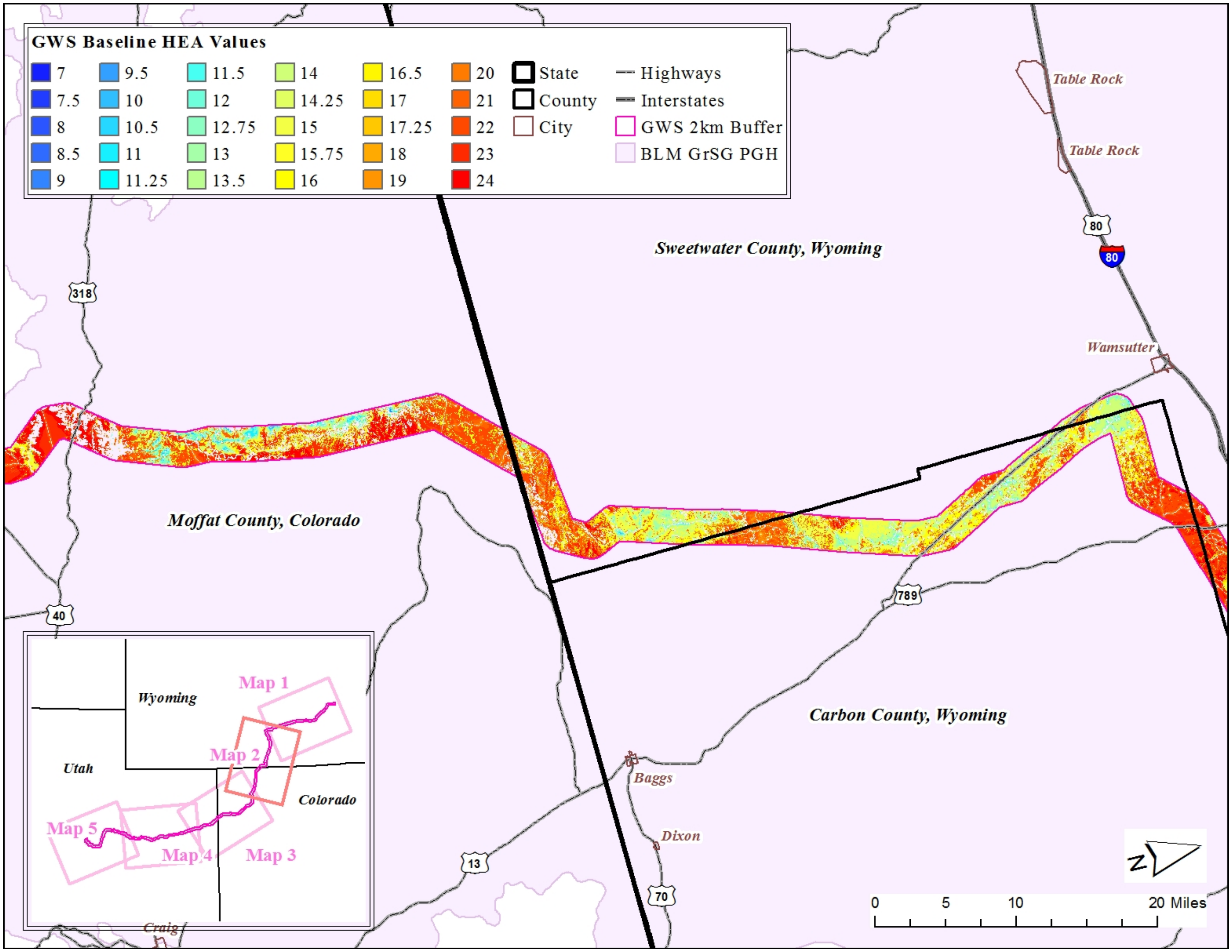


Figure 5. GWS baseline HEA values (map 2 of 5).

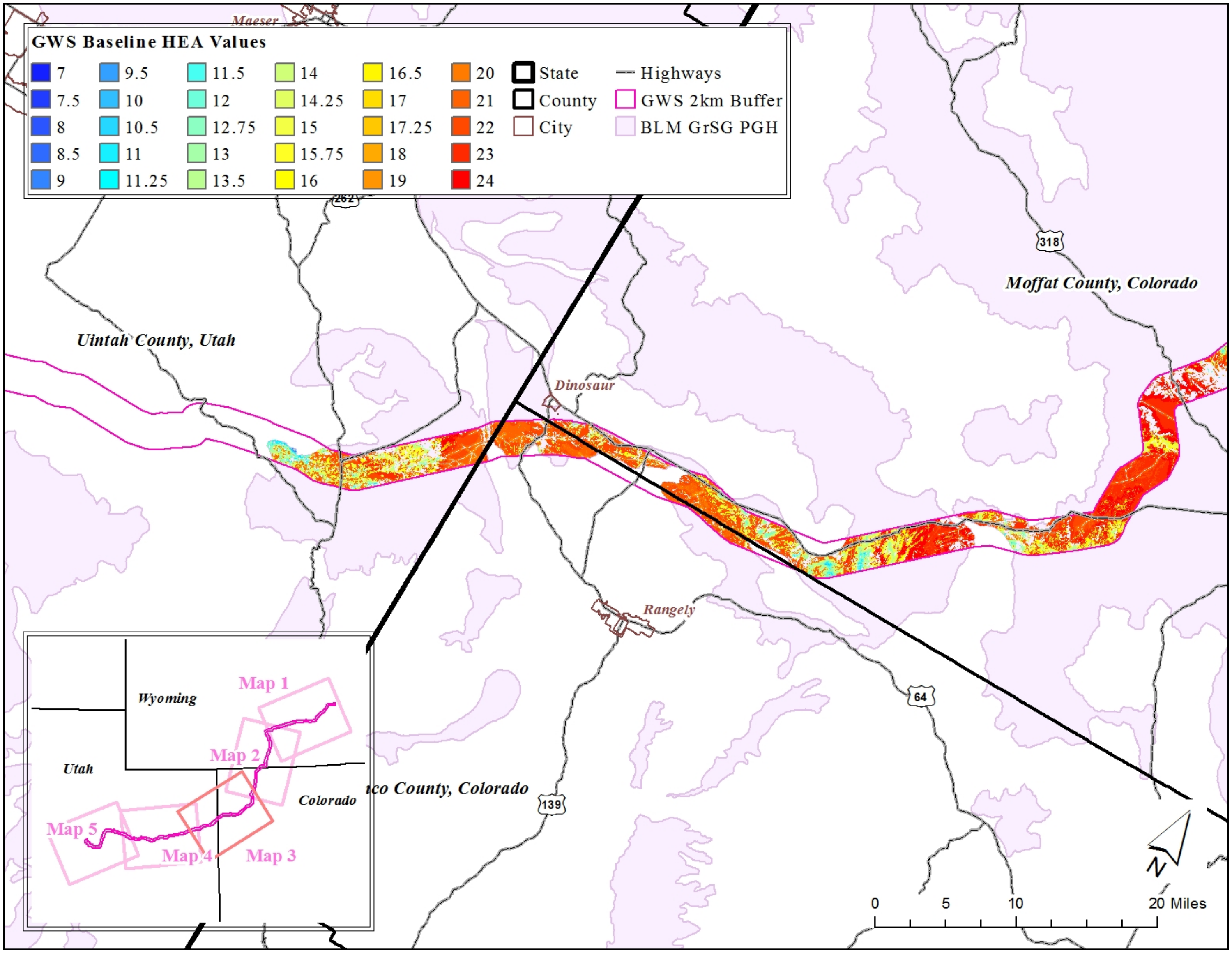


Figure 6. GWS baseline HEA values (map 3 of 5).

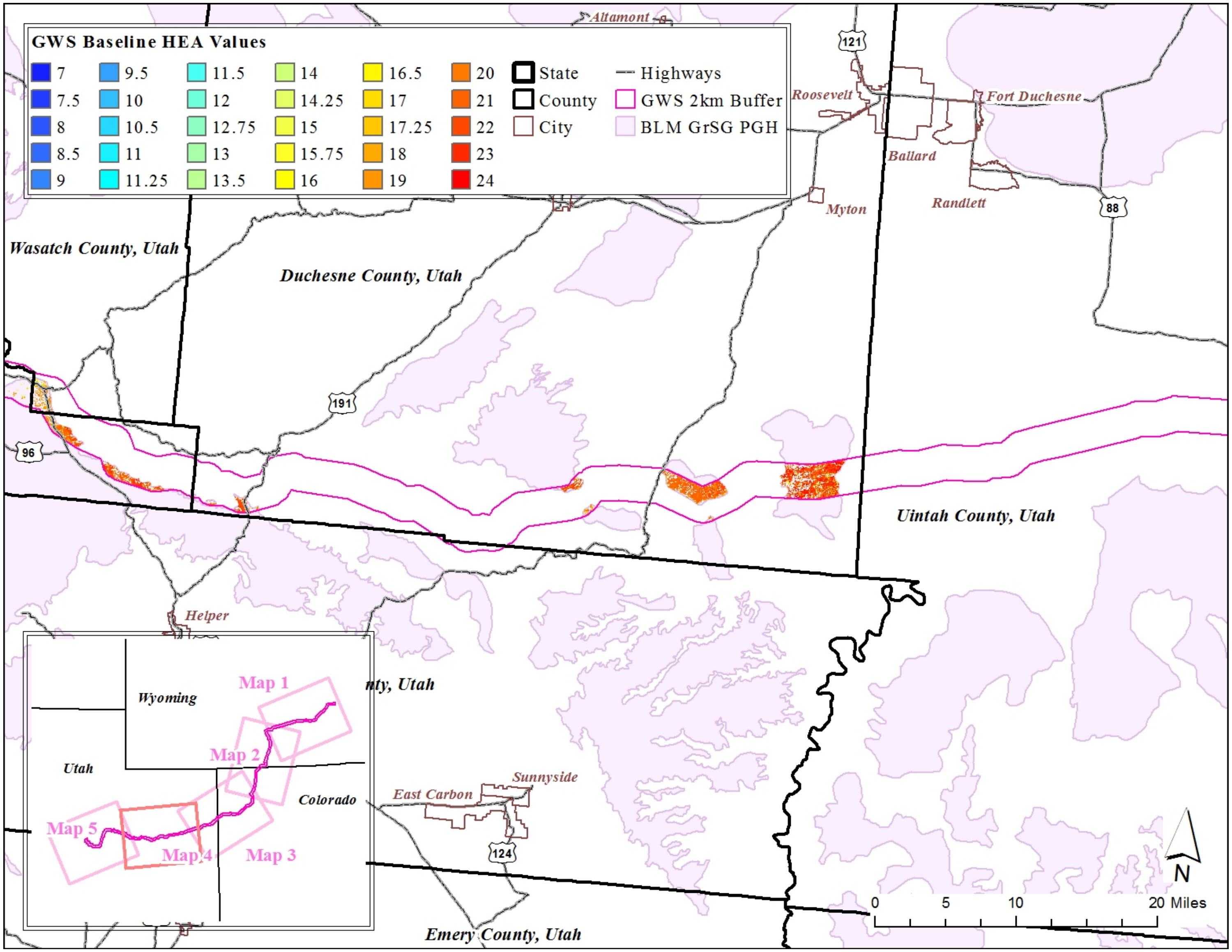


Figure 7. GWS baseline HEA values (map 4 of 5).

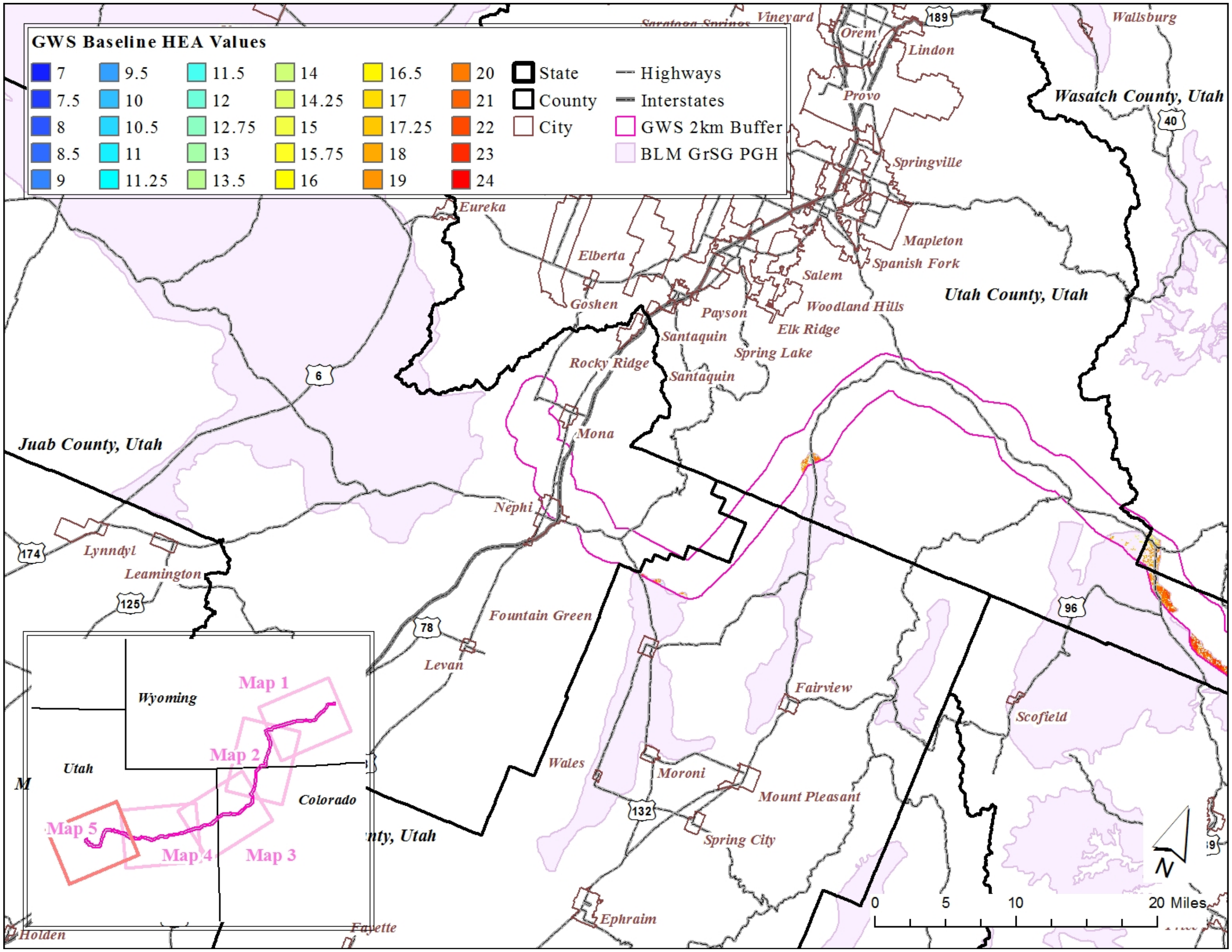


Figure 8. GWS baseline HEA values (map 5 of 5).

5.2.3 Restoration

The restoration milestone quantifies habitat services available to greater sage-grouse after construction is complete with some services returning with the reduction in noise and human presence.

Direct Disturbance

In the restoration year following construction, direct disturbance was still defined as the loss of all habitat services in the construction footprint because the vegetation had not regrown sufficiently to provide habitat. In order to quantify the footprint of the access roads within the project area during restoration, new access roads and previously-existing unpaved low-use roads were assumed to have a width of 20 m, reduced from the 50 m width used to model construction, as they would not be maintained as permanent roads once construction was complete and the adjacent habitats are again usable by sage-grouse. Previously-existing access roads (paved roads or heavily-traveled gravel roads only) were maintained at 50 m in width as they would be maintained as permanent roads post-construction and Variable 02 (Table 1) still applies. The actual road widths will be narrower than the modeled road widths. The width of the permanent roads reflects the surface area of the road as well as the area not usable by sage-grouse (see Appendix A, Section A.1.1). The width of the temporary roads at restoration was chosen so that the impacts would be detectable at the scale modeled, potentially overestimating the impacts of temporary access roads.

Indirect Disturbance

The two series compensation stations are the only indirect impact that remains after construction is complete, other than features modeled as having an indirect impact at baseline (e.g., paved roads). The noise associated with the operation of these stations was characterized as a permanent indirect disturbance in the model and is treated with the same impact buffers as items in Variable 02 and is included as part of Variable 02's additive score in the HEA. In other words, the area around the series compensation stations receives a score of 0 for the actual footprint and the first 25 m outside the footprint; a score of 1 for the area within 25 to 50 m of the footprint; a score of 2 for the area within 50 to 200 m of the footprint; and a score of 3 for areas outside of the 200-m buffer from the footprint.

Road buffers defined by the habitat service metric (Variable 01 and Variable 02) were applied to the centerline of permanent roads that are paved or heavily traveled. Unpaved access roads were assumed to be to be lightly traveled during restoration and have no modeled indirect impact, regardless of their maintenance into the future.

Little information has been published on greater sage-grouse habitat use near transmission lines. PacifiCorp decided not to model disturbance due to transmission lines because insufficient information was available to characterize and quantify these effects. Potential indirect impacts associated with transmission lines are discussed in detail in the Project's EIS (BLM 2014).

5.2.4 Recovery

There are four recovery milestones that quantify habitat services available to greater sage-grouse after a vegetation type has recovered to the greatest extent expected after the Project restoration is complete. Habitat services return to baseline conditions in restored areas with the time to recovery being dependent on the vegetation type.

Direct Disturbance

In the recovery years, direct disturbance was defined as the loss of all habitat services in the footprint of permanent facilities (i.e., the series compensation stations and transmission structure pads). Temporary access roads build during construction were assumed to have a width of 20 m and the vegetation was modeled to recover in this footprint over time. Access roads that existed prior to construction were assumed to be 50 m in width as they would be maintained as permanent roads post-construction. The direct disturbance in restored areas was returned at different rates depending on baseline vegetation type. There were four vegetation-based recovery endpoints: 1) agriculture and wetland (1 year after restoration); 2) grassland and riparian (5 years after restoration), 3) shrubs other than sagebrush (20 years after restoration); and 4) sagebrush (100 years after restoration). The assignment of the GAP vegetation types to these four recovery endpoints is described in Appendix E.

Indirect Disturbance

The series compensation stations are the only Project-related indirect impacts that are modeled after construction is complete. There may be additional indirect impacts of unknown magnitude and extent that were not modeled; these indirect impacts will be addressed separately in PacifiCorp's mitigation plan for Gateway South. The noise associated with the operation of the stations was characterized as a permanent indirect disturbance in the model and is treated with the same impact buffers as items in Variable 02 (paved and heavily-used gravel roads) and is included as part of Variable 02's additive score in the HEA. In other words, the area around the series compensation stations receive a score of 0 for the actual footprint and the first 25 m outside the footprint; a score of 1 for the area within 25 to 50 m of the footprint; a score of 2 for the area within 50 to 200 m of the footprint; and a score of 3 for areas outside of the 200-m buffer from the footprint.

Little information has been published on greater sage-grouse habitat use near transmission lines. PacifiCorp decided not to model disturbance due to transmission lines because insufficient information was available to characterize and quantify these effects. Potential indirect impacts associated with transmission lines are discussed in detail in the Project's draft EIS (BLM 2013).

5.3 Quantification of Conservation Benefit to Habitat Services

Habitat conservation measures (Table 4) were selected by the HEA Technical Advisory Team to be modeled in the HEA. These measures have been identified to improve greater sage-grouse habitat services and produce a benefit that could be measured by the habitat service metric used in this HEA. Furthermore, they are consistent with the conservation measures recommended by the COR (USFWS 2013; Appendix F). Specifically, the measures are summarized as follows.

- Fence marking with permanent markers is recommended by the COR to reduce collision-related mortality within 2 km of leks. Fence removal is recommended where fences are unnecessary.
- Sagebrush restoration and improvement projects are appropriate for use in areas designated by the COR as priority areas for conservation. It is recommended that the mitigation plan prioritize these areas for planned habitat conservation projects.
- Juniper/conifer removal using mechanical methods as proposed is consistent with the COR's recommendation for pinyon and/or juniper removal.

- Conservation easements can be used to limit future urban and exurban development in sage-grouse habitats, as recommended by the COR. Again, it is recommended that the mitigation plan prioritize areas designated by the COR as being priority areas for conservation.

The HEA-modeled conservation measures serve as a "toolbox" from which mitigation options may be selected by PacifiCorp for inclusion in a mitigation package. The benefit (in service-acres) for each habitat conservation measure was calculated with GIS technology, using the same habitat service metric as was used to calculate habitat service losses. It should be noted that proposed mitigation may not be limited to the modeled conservation measures. The benefit of some measures could not be measured using the habitat service metric (e.g., improvement of brood rearing habitat, improvement of understory vegetation). If these unmodeled conservation measures are proposed in the mitigation plan, their relative value will determined using a different method.

The same conservative vegetation growth rates that were used to model vegetation recovery in the Project footprint were applied to the habitat conservation measures proposed for mitigation. Conservative growth rates offset the potential for mitigation project failure in the model.

Table 4. Potential Mitigation Projects Modeled in the HEA

Mitigation Project Type	Brief Project Description	Anticipated Benefits	Average Cost of Implementation*,§
Fence removal and marking with flight diverters	Fences would be removed or marked in: 1) sections of fence known to cause greater sage-grouse collisions; 2) within 2 km (1.2 miles) of leks (Stevens et al. 2013) or other high risk areas; 3) in areas with low slope and terrain ruggedness (Stevens 2011); and 4) where segments are bounded by steel t-posts with spans greater than 4 m (Stevens 2011).	• Reduce mortality due to greater sage-grouse collisions • Increase visibility of fences, where diverters are used • Increase contiguous patches of shrub-steppe habitat • Remove localized grazing pressure where fences are removed, thereby increasing local habitat quality (e.g., bunchgrass cover)	$1,485 per mile ($920 per km) for fence removal or initial installation of flight diverters, and $320 per mile per year ($200 per km per year) for maintenance on flight diverters†
Sagebrush restoration and improvement projects	Seeding, planting seedlings, or transplanting containerized sagebrush plants (one plant per 5 m^2)	• Create contiguous patches of shrub-steppe habitat with optimal sagebrush cover and height • Increase availability of high-quality nesting, brood rearing, and winter habitats	$3,975 to $7,320 per acre ($9,820 to $18,090 per hectare) depending on method used ^
Juniper/conifer removal	Mechanical removal (lop and scatter, cut-pile-cover, or mastication) of juniper/confer adjacent to areas with optimal sagebrush cover and height.	• Reverse juniper/conifer encroachment on shrub-steppe habitat to increase contiguous patches of greater sage-grouse habitat • Increase light penetration to support a forb and grass understory	$180 to $2,120 per acre ($445 to $5,240 per hectare) depending on density of vegetation removed ‡
Conservation easements	Removes threat of specific land uses to sensitive wildlife populations.	• Prevent greater sage-grouse habitat destruction or degradation near urban areas and oil and gas development • Reduce future fragmentation of shrub-steppe habitat	$615 per acre ($1,515 per hectare) average purchase price $2,650 per year for each easement for maintenance and monitoring

* Cost of implementation includes a 50% markup for indirect costs, which include contract writing, supervision, clearances, monitoring, inspections, and vehicle costs.

† The cost of maintenance for the lifetime of the Project is included in the HEA model and is reflected in the resulting estimated cost per service-acre-year in Table 6.

‡ The cost of this treatment varies widely depending on the baseline vegetation. The lower end cost includes lop and scatter of Phase I juniper with no understory treatment. The upper end cost includes mastication of Phase III juniper and seeding a bunchgrass understory.

§ Costs were estimated for the Gateway West Transmission Line HEA (BLM 2013) and then adjusted using a 3% inflation rate to bring them up to 2014 dollars. Mitigation funds provided in years after 2014 should be further adjusted for inflation.

^ Cost estimates include seeding a bunchgrass understory, although the benefit of a bunchgrass understory could not be measured by the HEA metric.

km = kilometer   m = meter

Three to five hypothetical mitigation project areas were selected to model each conservation measure. The variable scores were manipulated using GIS technology to approximate the change expected with implementation of the measure. The benefit of the measure was the difference in the service score before and after implementation. The mean benefit among the hypothetical mitigation project areas was entered into the HEA, where estimated time until full benefit and discount rate was applied to estimate the discounted service-acre-years gained per mitigation project area. The HEA assumed that the mitigation projects would be funded in the first year of the Project construction.

The cost of the modeled habitat conservation measures was estimated by averaging the known cost of similar conservation projects previously implemented in Idaho and Wyoming—cost estimates from the Gateway West HEA (BLM 2013) were adjusted using a 3% annual inflation rate (equal to the discount rate used in this HEA) to bring the costs up to 2014 dollars. These cost estimates were used to calculate the price per service-acre-year. An HEA scales the mitigation package (i.e., funding to create habitat services) to offset the loss of habitat services over the lifetime of the Project. Appendix D describes the calculation used to quantify the benefit of the mitigation projects compared to baseline.

6.0 Habitat Equivalency Analysis Results

The following sections describe the results of the HEA for habitat service losses over the lifetime of the Project and the results of the HEA for conservation measure benefits. These results are expressed as the discounted service-acre-years (DSAYs) lost or gained, which is the sum of the permanent and temporary losses and gains over the lifetime of the Project with the economic discount rate applied. These results may be used to scale mitigation.

6.1 HEA Habitat Service Loss Results

A separate HEA was run for each state where the Project intersected greater sage-grouse habitat (Colorado, Utah, and Wyoming). The modeled habitat service level at each of the Project milestones was entered into the HEA to calculate the present value of the habitat services lost over the lifetime of the Project. A linear change in service level was assumed between modeled milestones. A summary of the estimated habitat service losses due to the Project's construction, operation, and maintenance are provided in Table 5 for the full Analysis Area (i.e., 2-km buffer around Project footprint). These are the habitat service totals that need to be offset with mitigation. Service losses varied among states with differences in the buffered Project centerline that intersected greater sage-grouse PGH, differences in baseline habitat quality, and the type of development.

6.2 HEA Conservation Benefit Results

A separate HEA was run for each habitat conservation measure. The habitat service increases modeled using GIS-based tools were entered into the HEA, along with estimates of time between receipt of funding and implementation of the measure, and time between implementation of the measure and full service benefit from the measure. The habitat service gains per unit area treated summed over the lifetime of the Project are provided for each conservation measure in Table 6.

New habitat services (measured in DSAYs) and cost per services gained varied among conservation measures. Conservation easements preserve existing habitat services in areas of potential development and can create new habitat services if existing land practices that are damaging to greater sage-grouse habitat are restricted.

Table 5. Habitat Services Lost in the Analysis Area Over the Lifetime of the Project

State	Permanent Disturbances Modeled	Total Project Length (km)	Total Project Footprint Area (acres)	Assessment Area† Length (km)	Assessment Area† (acres)	Habitat Services in the Assessment Area at Baseline Condition (DSAYs)+	Habitat Services Lost in the Assessment Area (DSAYs)+
Colorado	series compensation station transmission tower pads*	146	1,264	139	130,539	70,805,827	1,524,341
Utah	series compensation station transmission tower pads*	304	2,581	36	42,720	19,313,241	564,024
Wyoming	transmission tower pads*	227	1,749	227	224,995	130,751,006	2,405,120
Total	series compensation stations transmission tower pads*	676	5,594	401	398,254	220,870,074	4,493,485

* 360 $feet^2$
† Area in BLM PGH
+ Summed over the lifetime of the Project
km = kilometer
PGH = preliminary general habitat
DSAY = discounted service-acre-year

Table 6. Mean Present Value Habitat-Service-Acre Gained and Average Cost for Each Habitat Conservation Measure

Conservation Measure	General Method	Mean Habitat Services Gained (DSAYs/unit)	Cost per Services Gained (U.S.$/DSAY) [‡]
Fence removal and marking with flight diverters*	Fence marking within 3 km of leks and in other high risk areas (e.g., winter concentration areas, movement corridors)	3,597 per mile of fence marked	$9.57
	Fence removal within 2 km of leks and in other high risk areas	3,597 per mile of fence removed	$0.41
Sagebrush restoration and improvement projects	Seeding sagebrush	1,751 per acre of disturbance treated	$2.27 [^]
	Transplanting containerized sagebrush stems	4,556 per acre of disturbance treated	$1.61 [^]
	Planting seedlings	1,935 per acre of disturbance treated	$2.30 [^]
Juniper/conifer removal	Lop and scatter Phase I[†] juniper	480 per acre treated	$0.38
	Cut-pile-cover or mastication of Phase II[†] juniper	328 per acre treated	$2.11
	Mastication of Phase III[†] juniper and seeding bunchgrass understory	197 per acre treated	$10.76
Conservation easements	Land purchase (baseline value service credit) applying the annual maintenance and monitoring fee to every 5,000 acres of easement	650 per acre purchased[§]	$1.03

* Although fence removal is more effective at removing the threat of greater sage-grouse collision than fence marking, both measures were modeled as having the same benefit due to a limitation in the model. The cost of fence removal is lower than marking because no ongoing maintenance is required and 100 years of maintenance is assumed for marked fences.

[†] Phases of juniper describe the dominance of this vegetation on the landscape. Phase I is a sagebrush-dominated landscape with scattered juniper, Phase II is a landscape comprising a 50:50 mixture of sagebrush and juniper, and Phase III is a landscape dominated by juniper.

[‡] Cost estimates include permitting and maintenance.

[§] Estimated using the average habitat services value per acre in the Assessment Area, excluding scores of 0, because no specific easements have been proposed.

[^] Cost estimates include the price to seed a bunchgrass understory.

DSAY = discounted service-acre-year

km = kilometer

6.3 Application of Results to a Mitigation Package

PacifiCorp, BLM, and agencies will evaluate the services returned per habitat conservation measure, compare those services gained to the services lost as a result of the Project, and develop an appropriate mitigation plan to compensate for services lost. This analysis is a decision-making support tool for the development of the mitigation plan.

To accomplish a 1:1 trade-off in habitat service-acre-years over the lifetime of the Project per a traditional HEA, habitat conservation measures from Table 6 should be selected to offset 100% of the habitat service losses quantified for each state in Table 5. The recommended approach to this process is outlined in the steps below.

1. Select the habitat conservation measures most appropriate for each segment from Table 6 and define the percent of each measure to be used as mitigation.
2. Calculate the habitat services to be replaced using each habitat conservation measure. The total of the habitat services replaced using each measure should equal the total services lost in Table 5.
3. Calculate the cost to implement each habitat conservation measure in each segment. Multiply the habitat services to be replaced using a measure by the cost per habitat services gained for that measure from Table 6.
4. Sum the costs of the habitat conservation projects separately for each segment. The total would be the mitigation for the modeled habitat service losses in that segment.

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APPENDIX A

Greater Sage-grouse Habitat Service Metric for the Gateway South Project

A. Development of Habitat Service Metric for Habitat Equivalency Analysis

A habitat service metric was developed for the greater sage-grouse (*Centrocercus urophasianus*) using variables identified in the peer-reviewed literature as representative of greater sage-grouse habitat. Habitat service levels are intended to reflect both the quality of the habitat and the ability of the birds to use the habitat. For each of the eight metric variables, a habitat service score ranging from 0 to 3 (no services [contributing no value to habitat] to high services [optimal habitat]) was assigned, similar to the greater sage-grouse habitat assessment framework developed by Stiver et al. (2010) and the greater sage-grouse habitat suitability index developed by LaGory et al. (2012). Scoring habitat services is a critical step in the habitat equivalency analysis (HEA) process because it provides a way to measure the relative quality of specific habitat functions in a specific area.

The scores for this HEA are primarily based on information contained in the literature regarding greater sage-grouse habitat use and selection. When literature did not allow for direct assignment of value ranges for HEA scores, professional judgments were used. Professional judgments are associated with specific literature references when possible and/or confirmed with academic and agency biologists.

When a basic life requisite of greater sage-grouse is absent (vegetation is absent, the area is forested, or high levels of disturbance are present), the cell being scored is assigned a total service value of 0. When a measurements for particular variable within the metric (e.g., Variable 06, % sagebrush canopy cover) matches literature-based descriptions of sub-optimal conditions, that variable is given a service score of 0 (contributing no value to habitat), 1 (poor habitat), 2 (moderate habitat), or 3 (optimal habitat). For example, sagebrush canopy cover <1% would score a 0, canopy cover of 1% to 5% would score a 1, canopy cover of 5% to 15% or >35% would score a 2, and 15% to 35% canopy cover would score a 3 for that variable.

Scoring of the variables is categorical and each variable is given the same weight in the model. This approach is based on the best available data and is consistent with the general approach of LaGory et al. (2012, page 8) which is described as follows.

> In general, there was insufficient information in existing studies to determine relationships among variables and habitat suitability or relative contributions between variables/components. Therefore, for simplicity, we developed piecewise linear functions of suitability based on the assumption that all variables are of equal weight and applied these functions to geospatial layers to generate indices ranging from 0 (poor) to 100 (optimal). This approach is similar to that used for many of the U.S. Fish and Wildlife Service (USFWS) Habitat Suitability Index models in their Habitat Evaluation Procedure (available at http://www.fws.gov/policy/ESMindex.html).

While the individual variables are not weighted, the number of variables relating to a habitat attribute (e.g., six for vegetation vs. one for slope) and the size of the buffers (e.g., 1,000 meters [m] for high traffic roads vs. 200 m for low traffic roads) give some attribute categories more influence than others. In the metric, there are three variables that score sagebrush characteristics (sagebrush abundance index, sagebrush % canopy cover, and sagebrush canopy height), so areas that are not dominated by sagebrush will score low for these three variables, resulting in a lower overall score.

Greater sage-grouse habitat suitability publications vary in their baseline environmental conditions affecting a particular study site. Even studies within the same state may describe different suitable habitat conditions depending on elevation, precipitation zone, and other geographic or climatic factors affecting each study site.

No specific habitat studies have been conducted on the Gateway South Transmission Project's (GWS Project's) transmission line corridor alternatives, therefore the habitat metrics described below mostly rely on information presented in Bureau of Land Management (BLM) et al. (2000), Cagney et al. (2009), Connelly et al. (2000), Connelly et al. (2011), and other summary publications. Specific citations are given to support the habitat model framework when applicable.

A single habitat service metric is applied to the entire GWS Project corridor in order to standardize results. This approach assumes that optimal habitat or poor habitat for greater sage-grouse looks the same (that is, measures the same for the variables in the metric) regardless of its location, despite regional differences in habitat features and availability.

As a result, the best available habitat at the edge of the species' range may not score as high as the best available habitat in the center of the species' range, unless they have the same measurements for the variables in the metric. The following sections describe the development of the habitat service model variables.

A.1 Metrics of Greater Sage-grouse Habitat Services

The metric is only applied to areas that contain greater sage-grouse habitat by first only analyzing those areas that fall within the BLM's Priority General Habitat (PGH). Next, land cover types that are typically avoided by greater sage-grouse, also known as excluded lands, were assigned an overall metric score of 0 before the additive metric is applied to the remaining areas. Because these excluded lands have an HEA value of zero, disturbances of these lands require no mitigation in the HEA. These land cover types include all forest types, urban areas, open water, some introduced vegetation types, roadways and those areas <100 m from roadways with >6,000 annual average daily traffic (AADT) and <25 m of paved roads with <6,000 AADT), as well as well pads and mine footprints plus areas <25 m from the footprints (multiple sources per U.S. Fish and Wildlife Service listing decision in *Federal Register*; Johnson et al. 2011).

The metric for greater sage-grouse habitat services used in this HEA is an additive model (Table A.1) with a score adjustment for the presence of fences posing a high collision risk to greater sage-grouse during the lekking season. Each 30- by 30-m cell in the analysis area (within 2-kilometer [km] buffer from the project centerline) is scored separately by summing the scores of Variables 01 through 08 in that cell. The summed score is then multiplied by a factor that reduces the score where high risk fences are present. Each of the variables and the fence score adjustment is described in detail below.

Table A.1. Additive Variables in the Metric of Greater Sage-grouse Habitat Services

Variable Number	Variables Description	HEA Score Criteria				Primary Citations^
		3	2	1	0	
VAR01	Distance to high-traffic (>6,000 AADT) road, such as an interstate, federal, or state highway (meters)	>1,000	650–1,000	100–650	<100*	Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR02	Distance to low-traffic (<6,000 AADT) paved roads, heavily travelled gravel roads, well pads, mine footprints, transmission substations (meters)	>200	50–200	25–50	<25*	Connelly et al. (2004); Craighead Beringia South (2008); Johnson et al. (2011); Pruett et al. (2009)
VAR03	Percent slope	<10	10–30	30–40	>40	Beck (1977); Lincoln County Sage Grouse Technical Review Team (2004)
VAR04	Distance to occupied lek† (kilometers)	0–6.4	6.4–8.5	>8.5	N/A	Cagney et al. (2009); Connelly et al. (2000); Connelly et al. (2011); Holloran and Anderson (2005)
VAR05	Sagebrush abundance index (% of vegetation that is sagebrush within a 1-square-kilometer moving window)	50–95	30–50 or >95	10–30	0–10	Carpenter et al. (2010); Walker et al. (2007); Aldridge and Boyce (2007); Aldridge et al. (2008); Wisdom et al. (2011)
VAR06	Percent sagebrush canopy cover	15–35	5–15 or >35	1–5	<1	Cagney et al. (2009); Connelly et al. (2000); Stiver et al. (2010)
VAR07	Sagebrush canopy height (centimeters)	30–80	20 to <30 or >80	5–20	<5	Crawford et al. (2004); Connelly et al. (2000); Stiver et al. (2010)
VAR08	Distance of habitat to sage or shrub dominant (meters)	<90	90–275	275–1,000	>1,000	BLM et al. (2000); Connelly et al. (2000); Lincoln County Sage Grouse Technical Review Team (2004)

* Lands less than 100 meters from a high traffic road and less than 25 meters from a low traffic paved road or high traffic gravel road were given a total metric score of 0 (provides no habitat services), not just a score of 0 for these individual variables.

^ Greater sage-grouse habitat suitability publications vary in their descriptions of the baseline environmental conditions affecting a particular study site. Even studies within a single state may describe different suitable habitat conditions depending on elevation, precipitation zone, and other geographic or climatic factors affecting each study site. The habitat metric relied on generalizations presented in BLM et al. (2000), Cagney et al. (2009), Connelly et al. (2011), Connelly et al. (2000), Stiver et al. (2010), and other summary publications. Specific citations are given to support these generalizations when applicable. The same metric of habitat services was applied to the entire GWS Project area.

† Leks were classified as occupied if their 10-year attendance average was greater than 0.

AADT = annual average daily traffic

A.1.1 VAR01 and VAR02: Distance to Roads and Highways

Research into the effects of roads on greater sage-grouse is varied. For instance, in Colorado, Rogers (1964) mapped 120 leks with regard to distance from roads and found that 42% of leks were over 1.6 km (1 mile) from the nearest improved road, but that 26% of leks were within about 90 m (about 100 yards) of a county or state highway, and two leks were on a road. Connelly et al. (2004) also noted sage-grouse using roads for lek sites. In contrast, Craighead Beringia South (2008) reported results from a 2007 to 2009 study of greater sage-grouse seasonal habitat use in Jackson Hole, Wyoming. Results indicate that greater sage-grouse avoid areas within approximately 100 m of paved roads. Similarly, Pruett et al. (2009) found that lesser prairie-chickens (*Tympanuchus pallidicinctus*) avoided one of the two highways in the study by 100 m; however, some prairie-chickens crossed roads and had home ranges that overlapped the highways, thus roads did not completely exclude them from neighboring habitat. Johnson et al. (2011) examined the correlation between trends in lek attendance and the environmental and anthropogenic features within 5- and 18-km buffers around leks. They found that lek attendance declined over time with length of interstate highway within 5 km, although the authors note that this trend was based on relatively few data points and no pre-highway data were available for comparison. Interstate highways >5 km away and smaller state and federal highways had little or no effect on trends in lek attendance. Thresholds less than 5 km were not examined.

In the habitat services metric, Variable 01 is high-traffic road (>6,000 AADT), such as an interstate or U.S. highway, or state highway, and Variable 02 is low-traffic (<6,000 AADT) paved or unpaved roads. Those habitats within 100 m of Variable 01 roads and within 25 m of Variable 02 roads were considered to be excluded lands and therefore were given an overall score of 0 in the additive HEA model. In addition, in order to characterize the disturbance of mining, oil and gas, and other commercial vehicles, mine footprints and well pad footprints were classified and scored as if they were Variable 02 low-traffic roads making habitats within 25 m of these areas excluded lands as well. Finally, the Series Compression Station will also be classified and scored as if it is a Variable 02 low-traffic road in the model and habitats within 25 m of this area will also be considered excluded lands to help account for the noise and human presence associated with this facility.

Those habitats located farther than 1,000 m and 200 m of Variable 01 and Variable 02 roads, respectively, were considered the most serviceable to greater sage-grouse (that is, exhibited no decrease in lek attendance) and were given a score of 3. A logarithmic curve was fit between the highest and lowest categories so that score increased with distance from the road to estimate the distance breaks associated with scores 1 and 2. A logarithmic rate of change simulates sound attenuation rates better than a linear rate of change (Crocker 2007). Conflicting research results regarding greater sage-grouse use near and on unpaved resource/collector roads (e.g., two-track roads) did not allow for quantification of the disturbance caused by these roads in the model.

While the application of distances to all scores (0–3) is not perfectly supported in the peer-reviewed literature, our approach places a penalty upon habitats that are bisected by all types of large roadways. Penalties are higher for roads that typically have higher traffic levels and risk to greater sage-grouse (e.g., mortality from collision, noise disturbance) than less-utilized secondary roads that generally have less traffic and implied risk.

A.1.2 VAR03: Percent Slope

Slope was used to refine greater sage-grouse habitat potential. Greater sage-grouse generally use flat or gently sloping terrain (Connelly et al. 2011; Eng and Schladweiler 1972; Nisbet et al. 1983; Rogers 1964). Beck (1977) plotted the distribution of 199 greater sage-grouse flocks in Colorado and found that 66% of flocks were on slopes less than 5% and only 13% of flocks were on slopes greater than 10%. Areas with slopes greater than 40% are unsuitable for nesting habitat (Lincoln County Sage Grouse Technical Review Team 2004), but still have some value to greater sage-grouse and should be retained in the model (professional judgment of the HEA Technical Advisory Team). Therefore, areas with less than 5% slope were assigned a habitat service score of 3, and those exceeding 10% subjectively received incrementally lower habitat service scores. Slopes >40% did not add value to the habitat and received a score of 0 for this variable, but these areas may provide habitat services depending on the scores for the other variables.

A terrain roughness index was evaluated for use in place of the slope variable, as some studies have shown that it is a better indicator of greater sage-grouse use (Carpenter et al. 2010; Doherty et al. 2008; Doherty et al. 2010; Dzialak et al. 2011). However, there was substantial variation in the methods used to calculate the terrain roughness index (e.g., measure of roughness used and analysis window size) and region evaluated (e.g., Alberta, Canada, vs. Powder River Basin, Wyoming) by these studies. Given this variation, it was not possible to identify literature-supported cutoffs between scores for use in the model.

A.1.3 VAR04: Distance to Lek (10-year Average Count >0 Males)

Current greater sage-grouse habitat management guidance uses occupied leks, a gathering of males for mating purposes, as focal points for nesting habitat management (Connelly et al. 2000; Connelly et al. 2011); therefore, distance to lek was used as a variable in the habitat services metric. These guidelines recommend protecting sagebrush communities within 3.2 km (2 miles) of a lek in uniformly distributed habitats and 5.0 km (3.1 miles) in non-uniformly distributed habitats. Holloran and Anderson (2005) studied nesting greater sage-grouse at 30 leks in central and western Wyoming and determined that 45% and 64% of female greater sage-grouse nested within 3.2 km and 5.0 km of the lek where the hen was radio-collared, respectively. Moreover, statistical analyses suggested that the area of interest for nesting greater sage-grouse should be truncated at 8.5 km (5.3 miles) from a lek. Similar frequencies are reported in Cagney et al. (2009)—66% within 5.0 km and 75% within 6.4 km (4 miles) of a lek where the female bred.

Female greater sage-grouse do nest at distances greater than 8.5 km (the farthest distance reported in Holloran and Anderson [2005] was 27.4 km [17 miles]), so all distances >8.5 km from occupied leks were given a service score of 1 to reflect some potential use by nesting greater sage-grouse. Areas within 6.4 km of a lek provide the highest service level, because they provide female grouse with forage, roost sites, and cover from predators or inclement weather during the lekking season, in addition to containing lekking habitat and nesting habitat (Cagney et al. 2009), and were assigned a service score of 3 for this variable. Areas between 6.4 and 8.5 km were assigned a score of 2 for this variable.

A.1.4 VAR05: Sagebrush Abundance Index

Sage-grouse are sagebrush obligates, thus sagebrush abundance and quality are strong predictors of sage-grouse use and persistence. Walker et al. (2007) found that the proportion of habitat that was sagebrush within a 6.4 km moving window was a strong predictor of lek persistence in the Powder River Basin of Wyoming. The moving window is an analysis area that is larger than and centered on the cell being scored; in this case, the window is a 6.4-km buffer that moves as the cell being scored is changed. Areas with less than 30% of sagebrush within 6.4 km of the lek center had a lower probability of lek persistence. Aldridge and Boyce (2007) also used a moving window (1 km^2) to measure sagebrush cover and abundance. Their resource selection function found that greater sage-grouse selected nesting habitat that contained large patches (1 km^2) of sagebrush with moderate canopy cover and moderate sagebrush abundance (i.e., heterogeneous distribution of sagebrush). Carpenter et al. (2010) found similar results in Alberta, Canada. Their top resource selection functions included a quadratic function for sagebrush abundance, which indicates that areas of moderate sagebrush abundance were selected more frequently than areas of homogenous sagebrush.

Aldridge et al. (2008) (per Wisdom et al. [2011]) found that at least 25% of the landscape in a 30.77-km (19.1-mile) analysis area needed to be dominated by sagebrush for greater sage-grouse persistence, with 65% being preferred. Wisdom et al. (2011) found that landscapes with less than 27% sagebrush were not different from landscapes from which greater sage-grouse have been extirpated. Similar to Aldridge et al. (2008), Wisdom et al. (2011) found that 50% sagebrush across a landscape was a good indicator of greater sage-grouse persistence.

Participants in the HEA Technical Advisory Team indicated that greater sage-grouse prefer higher sagebrush abundance in the southern part of their range than is indicated by these studies. For example, the Colorado Parks and Wildlife (CPW) Avian Research Center has generally found a positive linear relationship between sagebrush abundance and measures of habitat selection (Brian Holmes, Colorado Parks and Wildlife, personal communication with Jon Kehmeier, SWCA Environmental Consultants [SWCA], on February 13, 2013). CPW has not observed an upper inflection point in the proportion of the landscape covered in sagebrush where use or selection begins to drop, and suggest that the difference may be due to the structure and composition of the sagebrush community (that is, silver sagebrush mixed grassland rangelands of Alberta [Aldridge and Boyce 2007; Carpenter et al. 2010] vs. big sagebrush steppe [GWS Project area]).

Sagebrush covering 50% to 95% of the landscape scored a 3 for this variable (Aldridge et al. 2008; Wisdom et al. 2011; professional judgment of HEA Technical Advisory Team). Sagebrush covering 30% to 50% or >95% scored a 2 for this variable (Aldridge et al. 2008). Sagebrush covering 10% to 30% scored a 1 (Walker et al. 2007; Wisdom et al. 2011) and sagebrush covering less than 10% scored a 0 for this variable (professional judgment of HEA Technical Advisory Team).

A.1.5 VAR06: Sagebrush Canopy Cover

Recommended sagebrush canopy cover (the proportion of land area covered by sagebrush crowns, as viewed from the air) for greater sage-grouse habitat varies seasonally. Seasonal habitats were not modeled, but seasonal differences in the selection for sagebrush cover were considered when developing habitat services metrics. The seasonal habitat needs of greater sage-grouse are described below, followed by scoring of percent sagebrush cover in the habitat services metric.

Seasonal Habitat Use

Nesting

Connelly et al. (2000) cite 13 references to sagebrush coverage that range from 15% to 38% mean canopy cover surrounding the nest. Citations contained within Crawford et al. (2004) reported 12% to 20% cover and 41% cover in nesting habitat. In their species assessment, Connelly et al. (2000) conclude that 15% to 25% canopy cover is the recommended range for productive greater sage-grouse nesting habitat. This is also the range identified in the greater sage-grouse habitat assessment framework (Stiver et al. 2010) as providing the highest service level for greater sage-grouse based on a review of the available literature. Wallestad and Pyrah (1974) reported that successful nests were in stands where sagebrush cover approximated 27%. This cover range is used as a goal in some greater sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000). Cagney et al. (2009) guidelines for grazing in grouse habitat, which use information synthesized from over 300 sources, state that hens tend to select an average 23% live sagebrush canopy cover when selecting nesting sites.

Greater sage-grouse in Utah use habitats with higher sagebrush canopy cover than is observed in the northern and eastern portions of the species range, possibly due to the relative scarcity of understory grasses in Utah (Renee Chi, BLM, personal communication with Ann Widmer, SWCA, on March 22, 2013). Nest sites in Wildcat Knoll (part of the Emery-Sanpete population of Utah) were located in areas with an average of 33% shrub canopy cover for successful nests and 22% for unsuccessful nests (Perkins 2010). Nests in Parker Mountain were located at sites with an average canopy cover of 35.5% for big sagebrush and 32% for big sagebrush mixed with black sagebrush (Chi 2004; Renee Chi, BLM, personal communication with Ann Widmer, SWCA, on March 22, 2013). In the Sheeprock greater sage-grouse population, nest site shrub canopy cover measured an average of 62% in 2005 and 83.5% in 2006 (Robinson 2007).

Brood Rearing

Connelly et al. (2000) found that productive brood-rearing habitat should include 10% to 25% cover of sagebrush. This is the range used as a goal in greater sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000). While sagebrush is a vital component of greater sage-grouse habitat, very thick shrub cover may inhibit understory vegetation growth and reduce the birds' ability to detect predators (Wiebe and Martin 1998).

Again, greater sage-grouse in Utah may use areas with higher canopy cover than is typical throughout the northern and eastern parts of their range. Grouse in the Sheeprock population were documented using areas with an average shrub canopy cover of 73% during brood rearing in 2005 and 2006 (Robinson 2007).

Winter

Connelly et al. (2000) cite 10 references to sagebrush coverage in winter-use areas that range from 15% to 43% mean canopy cover (Crawford et al. [2004] also cite two of these references in their assessment); however, they considered a canopy of 10% to 30% cover above the snow as a characteristic of sagebrush needed for productive greater sage-grouse winter habitat. This is the cover range used as a goal in greater sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000). Greater sage-grouse in Utah may prefer higher cover in winter. In Emma Park, areas of high sagebrush cover were used disproportionally to their availability on the landscape, with an average of 38.3% sagebrush canopy cover in winter-use areas (Crompton and Mitchell 2005).

Scoring in Habitat Services Metric

In general, the recommended sagebrush cover for nesting habitats was intermediate to, and overlapped that of, brood-rearing and winter habitats. Thus, favorable conditions for nesting were given the highest scores for percent sagebrush cover in the greater sage-grouse habitat services metric.

This variable used the scores assigned by Stiver et al. (2010) for sagebrush cover categories in greater sage-grouse nesting habitat, with a slight adjustment to account for use of higher canopy cover in Utah. This adjustment is also consistent with the Colorado Greater Sage-Grouse Conservation Plan (Colorado Division of Wildlife et al. 2008). Sagebrush percent canopy cover of 15% to 35% was assumed to provide the highest level of services (score of 3) to nesting greater sage-grouse. This includes canopy covers that are 10% higher than the average ranges provided in Connelly et al. (2000) and Cagney et al. (2009). Areas with slightly less or more cover than this (55%–15% or >35%) were given a habitat services score of 2. Habitats with 1% to 5% cover received a score of 1 and those habitats with <1% cover received a score of 0.

A.1.6 VAR07: Sagebrush Canopy Height

Sagebrush canopy height is an important component of nesting and winter habitat, because it affects how well nests are concealed from predators and how much food is available above the snow. As described above, seasonal habitat models will not be developed for the GWS Project. However, seasonal habitat requirements were considered when developing habitat metric values. The seasonal habitat preferences of greater sage-grouse are described below and followed by the scoring of sagebrush height in the habitat services metric.

Seasonal Habitat Use

Nesting

Gregg et al. (1994, cited in Crawford et al. 2004) found that the area surrounding successful nests in Oregon consisted of medium-height (40 to 80 centimeters [cm]) sagebrush. Connelly et al. (2000) cite 11 references to sagebrush height that range from 29 to 79 cm mean height. In their assessment, Connelly et al. (2000) conclude that sagebrush with a height of 30 to 80 cm is needed for productive greater sage-grouse nesting habitat in arid sites and 40 to 80 cm in mesic (temperate) sites. These ranges are supported by Stiver et al. (2010) who recommend a range of 30 to 80 cm and BLM et al. (2000) who state that optimum greater sage-grouse nesting habitat consists of sagebrush stands containing plants 40 to 80 cm tall.

Winter

Important structural components in winter habitat include medium to tall (25–80 cm) sagebrush stands (Crawford et al. 2004). Connelly et al. (2000) cite 10 references for sagebrush height in winter habitat that range from 20 to 46 cm above the snow. Two studies measured the entire plant height and provided a range from 41 to 56 cm. In their assessment, Connelly et al. (2000) conclude that characteristics of productive winter habitat include sagebrush that is 25 to 35 cm in height above the snow. This is the height range used as a goal in greater sage-grouse management guidelines (Bohne et al. 2007; BLM et al. 2000).

Scoring in Habitat Services Metric

Sagebrush canopy heights that provided high-quality nesting habitat generally also provided high-quality winter habitat for greater sage-grouse. Thus, favorable conditions for nesting were given the highest scores for sagebrush canopy height in the greater sage-grouse habitat services metric.

The sagebrush cover scores assigned for nesting habitat in the greater sage-grouse habitat assessment framework by Stiver et al. (2010) to different sagebrush cover categories were assigned to this variable. Areas of sagebrush with a height of 30 to 80 cm were assigned a habitat services score of 3. As sagebrush canopy height decreases, the value of a sagebrush plant to provide cover for nesting females and their nests is diminished. Additionally, low-lying sagebrush is less available to greater sage-grouse during the winter due to snow cover. Areas with canopy heights greater than 80 cm provided intermediate levels of services because they may provide relatively poor cover for nesting greater sage-grouse and have foliage that is difficult for greater sage-grouse to access during mild and moderate winters. Consistent with Stiver et al. (2010), sites with sagebrush from 20 to 30 cm or >80 cm in height received a score of 2. Areas with minimal sagebrush canopy heights were considered to have the lowest habitat service value so sagebrush that ranged from 5 to 20 cm in height received a score of 1 and sagebrush that was <5 cm in height received a score of 0.

A.1.7 VAR08: Distance to Vegetation Dominated by Sagebrush or Shrub

Greater sage-grouse use shrubby habitats including sagebrush during the brood-rearing season (Connelly et al. 2000) and for grouse movement and dispersal (Stiver et al. 2010). Close proximity to shrubby vegetation increases the service value of all vegetation types modeled because shrubby vegetation provides cover from predators, facilitates grouse movement, and supports population connectivity.

The Lincoln County Sage Grouse Technical Review Team (2004) identified proximity to sagebrush cover as an important component in habitat suitability of non-sagebrush, brood-rearing habitats (e.g., mesic lowland habitats, hay meadows). The Team considered brood-rearing areas within <100 yards (91 m), 100 to 300 yards (275 m), and >300 yards of sagebrush cover as suitable, marginal, and unsuitable habitat, respectively. Similarly, Stiver et al. (2010) considered mesic habitats <90 m, 90 to 275 m, and >275 m of sagebrush to be suitable, marginal, and unsuitable late brood-rearing/summer habitat, respectively. These categorizations support the concept of increasing service level with proximity to shrubs, particularly sagebrush.

The distance to vegetation dominated by sagebrush or shrub variable (VAR08) measured the distance of the cell being scored (regardless of its vegetation type) to the next nearest cell that was dominated by sagebrush or a shrub species, including willows. For this variable, cells <90 m, 90 to 275 m, 275 to 1,000 m, and >1,000 m to a cell dominated by a shrub species were assigned scores of 3, 2, 1, and 0, respectively. The scoring was based on the breakpoints identified in the literature for distances up to 275 m and professional judgment by the HEA Technical Advisory Team for distances >275 m. The scores were applied to all vegetation types, because this variable is relevant to bird movement and dispersal from all habitat types.

A.1.8 Score Adjustment Factor: Fences that Pose a High Risk for Collision

Habitat within and surrounding the GWS Project transmission line corridor is currently influenced by fences used for livestock management. These fences are typically constructed from barbed wire and are used to control livestock movements and vegetation use within grazing allotments and pastures, to delineate or protect private property and agricultural croplands, and to restrict livestock from improved and unimproved roadways.

Fence collisions have been reported as a cause of significant injury and mortality to grouse species (greater sage-grouse [Braun 2006; Call and Maser 1985; Connelly et al. 2004; Christiansen 2009; Danvir 2002; Stevens, Connelly, et al. 2012]; lesser prairie-chicken [Wolfe et al. 2007]; ptarmigan [*Lagopus lagopus* and *L. mutus*] [Bevanger and Broseth 2000]; and red grouse [*Lagopus lagopus scoticus*], black grouse [*Tetrao tetrix*], and white capercaillie [*T. urogallus*] [Baines and Summers 1997; Catt et al. 1994; Petty 1995]). In addition to direct mortality, fences provide corridors for mammalian predators increasing the opportunity for predation of hens and broods (Braun 1998). Unlike the additive variables in the metric, which are primarily meant to characterize use and avoidance of habitat by greater sage-grouse, the distance to high risk fences was added to account for the potential direct loss of greater sage-grouse and not the greater sage-grouse avoidance of fences.

In Wyoming, Christiansen (2009) reported preliminary results of a multiple-year study (2005–ongoing) near Farson on greater sage-grouse fence strikes and mortalities and the utility of fence markers on reducing collisions. After installation of fence markers on portions of high-risk fences, grouse mortality decreased by 70%. Although the study did not compare the number of strikes with regard to distance to lek, the author recommends that fences should not be located within 0.25 mile (0.4 km) of leks.

In Idaho, Stevens (2011), Stevens, Connelly, et al. (2012), and Stevens, Reese, et al. (2012) evaluated the environmental features associated with greater sage-grouse fence collision risk and tested the efficacy of reflective vinyl fence markers to reduce collision rates at eight study sites. Modeling of these data predicted marking fences reduced collision rates by 74% to 83% at the mean lek size and fence distance from the lek during the breeding season. However, it should be noted that collision probability varied by region, topography, fence type, fence density, and lek proximity. Areas with high slope or terrain ruggedness generally showed lower collision risk than flat areas. Collisions were also more common on fence segments bound by steel t-posts with spans between posts exceeding 4 m. Collision probability increased with fence length per km^2 and proximity to nearest active lek.

For this variable, fences segments having a high risk for collision were identified using the model by Stevens et al. (2013), which is determines the fence-collision risk from proximity to lek and a terrain roughness index (Equation A.1).

Equation A.1

$$\hat{y} = 78 * \exp(\beta_0 + \beta_1 * TRI + \beta_2 * distance)$$

Where:

$\hat{y}$ is an estimate of the total number of greater sage-grouse collisions over a 78-day lekking season for each $900m^2$ pixel if a fence is present;

β_0 = -3.325 (regression intercept per Bryan Stevens, University of Idaho, personal communication with Ann Widmer, SWCA, on February 14, 2014);

β_1= -0.25;

β_2 = -0.0006;

TRI is a terrain roughness index calculated using ArcInfo; and

$distance$ is the distance from each 900m^2 pixel to the nearest greater sage-grouse lek in GIS using the Euclidean distance function (up to 3 km).

The additive metric score (the sum of VAR01 through VAR08) for a cell was multiplied by an adjustment factor that reduced if a fence intersected the cell and the cell was located within 3 km of a greater sage-grouse lek (i.e., it was scored by the Stevens et al. 2013 model). The adjustment factor for each probability of collision is provided in Table A.2. Allotment boundaries were used as a surrogate for fence lines. Following the convention established by Stevens et al. 2013, the arbitrary threshold of 1 grouse collision per lekking season was used as the breaking point between our score adjustment categories. The other category break was established based on a natural break in the data distribution.

Table A.2. Cell Score Adjustment for the Presence of Fences Posing a High Collision Risk

$\hat{y}$ (predicted total number of greater sage-grouse collisions per lekking season)	Score Adjustment Factor
0.00–<0.40	0.75
≥0.40–<1.00	0.50
≥1.00	0

Here are three examples of the application of the fence score adjustment factor. In the first, there is a cell with an additive score of 10 (the sum of VAR01–VAR08) that is located within 3 km of a lek and has a fence running through it. The Stevens et al. 2013 model predicts 0.2 collision per lekking season for a fence in that cell, so the additive score of 10 is multiplied by 0.75 for a final metric score of 7.5 for that cell. In the second example, there is another cell with an additive score of 10 that is located within 3 km of a lek and has a fence running through it. The Stevens et al. 2013 model predicts 1.4 collisions per year a fence in this cell, so the additive score of 10 is multiplied by 0 to produce a final metric score of 0 (no habitat services). In the third example, there is a cell with an additive score of 10 that has a fence running through it, but the cell is located 4 km from a lek. The Stevens et al. 2013 model does not produce an estimated number of collisions for this cell because it is located more than 3 km from a lek so the fence is considered to have a relatively low collision risk during the lekking season and the cell retains its full value (no adjustment).

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APPENDIX B

Quantification of Baseline Habitat Service Level

B. Quantification of Baseline Habitat Service Level

The pre-construction baseline of the habitat services was based on existing datasets to the extent possible. The baseline service level was determined by applying the habitat service metrics described in Appendix A to the Assessment Area that is identified for the Gateway South Transmission Project (GWS Project). The Assessment Area included the footprint of the Project and a 2-kilometer (km) buffer around the footprint, because greater sage-grouse (*Centrocercus urophasianus*) habitat service losses are expected to extend beyond the area of direct disturbance. In addition, the buffered footprint was clipped to the Bureau of Land Management's (BLM's) Priority General Habitat (PGH) boundaries.

ESRI ArcGIS 10.2 software and tools were used to conduct analyses. To facilitate calculations across the entire Assessment Area, all data were converted to a raster format that contained 30- by 30-m cells (900 m^2). This was done because raster processing is significantly faster for an analysis of this size as opposed to leaving the data raw (shapefiles).

B.1 Preparation of GIS Model Input Layers

Habitats within and surrounding the corridor for the preferred alternative are summarized in a series of representative raster layers for the eight additive metric variables and the fence adjustment factor (see Appendix A). These eight variables consist of data representations within the GWS Project area for human disturbance, landscape characteristics, proximity to greater sage-grouse lek locations, and vegetation characteristics that may influence the use of habitat by greater sage-grouse. A spatial resolution of 900 m^2 was sufficient to capture a landscape level perspective of habitat across the Assessment Area. The data used in the habitat equivalency analysis (HEA) are summarized in Table B.1. All data were georeferenced to the same projected coordinate system, NAD 1983 UTM Zone 12N.

Table B.3. GIS Data Sources

Variable	File Name	Description	File Type	Source
Fence Adjustment	BLM_Grazing_Allotments	Grazing Allotments	Shapefile	BLM
excluded lands, VAR07, VAR08	gaplndcov_co	30m National Gap Analysis Program land cover data - version 2	Raster	USGS
excluded lands, VAR07, VAR08	gaplndcov_ut	30m National Gap Analysis Program land cover data - version 2	Raster	USGS
excluded lands, VAR07, VAR08	gaplndcov_wy	30m National Gap Analysis Program land cover data - version 2	Raster	USGS
VAR01	ROADWAY.Major_Roads	Colorado Major Roads	SDE Feature Class	CDOT
VAR02	PermitData	Permitted Mines - Colorado	Shapefile	COGCC
VAR02	Wells_WY_20140107	Oil & Gas Wells - Wyoming	Shapefile	WOGCC
VAR02	DNROilGasWells	Oil & Gas Wells - Utah	Shapefile	CDNR
VAR02	Wells	Oil & Gas Wells - Colorado	Shapefile	COGCC
VAR02	Minerals	Mines and Minerals - Utah	Geodatabase	UDNR
VAR02	facilities	Open pit mines - Colorado	Shapefile	CDNR
VAR02	mineplant_fUS08	Mines - Colorado	Shapefile	USGS
VAR02	mineplant_fUS49	Mines - Utah	Shapefile	USGS
VAR02	mineplant_fUS56	Mines - Wyoming	Shapefile	USGS
VAR02	tl_2013_08081_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_08103_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_49007_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_49013_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_49023_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_49039_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_49047_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_49049_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_49051_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census

Variable	File Name	Description	File Type	Source
VAR02	tl_2013_56007_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
VAR02	tl_2013_56037_roads	All roads where MTFCC = S1100, S1200, S1400, S1630, S1640, S1740. County, St	Shapefile	US Census
Fences, VAR03, VAR05, VAR06, VAR07, VAR08	ned30_utm83	30 m resolution digital elevation data	Raster	USGS
Fence Adjustment, VAR04	CPW_GrSGLekCnt2013	Colorado Leks	Shapefile	CPW
VAR01	WYDOT_LRS	Wyoming Highways	Shapefile	WYDOT
VAR01	AADT	Utah Highways	Shapefile	UDOT
VAR05, VAR06, VAR07, VAR08	US_VDIST2008	Vegetation Distribution	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110VDEP	Vegetation Development	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110EVT	Exisisting Vegetation Type	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110CBD	Canopy Bulk Density	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110VCC	Canopy Cover	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110FLM	Fuel Loading Model	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110EVH	Exisisting Vegetation Height	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110CBH	Canopy Bulk Height	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_FDIST2008	Vegetation Disturbance	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110SCLASS	Succession Class	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110MFRI	Mean Fire Return Interval	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110BPS	Biophyisical Setting	Raster	USGS
VAR05, VAR06, VAR07, VAR08	US_110EVC	Existing Vegetation Cover	Raster	USGS
Fence Adjustment, VAR04	1383occleks	Wyoming Leks	Shapefile	WGFD
Fence Adjustment, VAR04	1383undetleks	Wyoming Leks	Shapefile	WGFD
Fence Adjustment, VAR04	Sage_Grouse_Leks_Occupied_Utah	Utah Leks	Shapefile	UNHP
Fence Adjustment, VAR04	Sage_Grouse_Leks_Price_Utah	Utah Leks	Shapefile	UNHP
Fence Adjustment, VAR04	Sage_Grouse_Leks_Utah_BLM_Vernal	Utah Leks	Shapefile	UNHP

B.2 Lands Assigned No Habitat Value

As described in Appendix A, land cover types and terrain features that do not provide suitable habitat for greater sage-grouse were removed from the HEA model. All vegetation types and landforms that potentially provide habitat for greater sage-grouse remained in the model (listed in Appendix E). Vegetation cover for the analysis was identified using the National Gap Analysis Program (GAP) Vegetation Classifications.

B.2.1 VAR 01 and VAR 02: Distance to Roads

Road layers used in developing the baseline HEA model are available from the state departments of transportation and from TIGER data from the U.S. Census Bureau. Road layers were compared between states to ensure consistency in classification prior to using them in the HEA model development. HEA model scores were applied to 30- by 30-m raster cells according to the process described in Table A.1.

In Variable 01, all cells that are more than 1,000 m from road centerlines with >6,000 annual average daily traffic (AADT) were given a score of 3; those between 650 and 1,000 m were given a score of 2; those between 100 and 650 m were given a score of 1; and those cells within 100 m were assigned a value of 0 habitat services in the model per the description provided in Appendix A (Metric of Greater Sage-grouse Habitat Services).

For Variable 02, all cells that are more than 200 m from road centerlines with <6,000 AADT were given a score of 3; those between 650 and 1,000 m were given a score of 2; those between 100 and 650 m were given a score of 1; and those cells within 100 m were assigned a value of 0 habitat services in the model per the description provided in Appendix A (Metric of Greater Sage-grouse Habitat Services).

B.2.2 VAR03: Percent Slope

The slope was calculated using 30- by 30-m digital elevation models obtained using 30-m National Elevation Dataset.

B.2.3 VAR04: Distance to Lek (10-year Average Count >0 Males)

Lek data were obtained from the wildlife management agencies in each state. Lek status was determined for all leks. Leks that have been active in the past 10 years or that have an unknown status were included in the HEA model. Those that are labeled as unoccupied or inactive were not included. Cells surrounding leks were scored according to the methods described in Appendix A with cells closest to leks receiving the highest scores.

B.2.4 VAR05: Sagebrush Abundance Index

A sagebrush abundance index was determined from available vegetation layers using Landfire data from the USGS by calculating the proportion of sagebrush in a 1 km^2 area surrounding each 30- by 30-m cell in the Assessment Area. Scores were applied using the methods described in Appendix A. Areas with a high proportion of sagebrush in the landscape and some habitat heterogeneity were scored higher than areas with little habitat heterogeneity or areas with little or no sagebrush.

B.2.5 VAR06 and VAR 07: Sagebrush Cover, Sagebrush Canopy Height

When possible, percent cover and height was determined directly from the vegetation attribute data included in the GAP and Landfire vegetation datasets. Where data were not available, attributes for percent cover and height were determined using other data sources. Sampling data from GAP/Landfire datasets as well as datasets obtained from BLM and the state agencies were used to attribute vegetation percent cover and height for segments of the landscape with the most similar characteristics. Once vegetation values were applied to the 30-m grid, HEA scores were applied using the methods described in Appendix A.

B.2.6 VAR08: Distance to Vegetation Dominated by Sagebrush or Shrub

The distance from each cell to the nearest sagebrush- or shrub-dominated cell was calculated. Cells within or closest to sagebrush or shrub landscapes were scored higher than those that are distant from shrub-dominated cells.

B.3 Score Adjustment Factor: Fences that Pose a High Risk for Collision

A raster file was produced by running the Stevens et al. (2013) model as described in Appendix A, Section A.1.8, to estimate the greater sage-grouse collision risk during the lekking season within 3 km of leks. The Stevens et al. (2013) model does not consider actual fence locations, so a separate fence location dataset was intersected with the results of the model to identify actual locations of high collision risk.

Fence locations were used if the data were available for the entire assessment area. In the event that fence data were not available, grazing allotment boundaries were used as surrogates for fence layers in the HEA baseline model development.

After the model results and fence layer were intersected, cells in the resulting raster file were assigned to different score adjustment factors as described in Appendix A. Every cell with a fence running through it that is located within 3 km of a lek had an estimated number of collisions per lekking seasons. If the estimate was between 0 and 0.39, the adjustment factor is 0.75. If the estimate was between 0.40 and 0.99, the adjustment factor is 0.50. If the estimate was 1.0 or above, the adjustment factor is 0 (i.e., cells containing the highest risk fences have no habitat value).

B.4 Summation of Baseline Services in the HEA Model

Below is a summation of the steps that were taken to produce a final HEA Service Raster for analysis in the HEA.

1. Rasters for each of the eight additive variables were added together to create an additive variable raster layer.
2. The additive variable raster layer was multiplied by a value of 0 or 1 to remove all excluded lands. 0 was used to represent an excluded land, which would therefore make the overall HEA value for any cell interesting it to be zero, while a 1 represents any areas that are not excluded lands which would retain the additive HEA value for any cell crossing it.

3. The raster that was created in step 2 was then multiplied by the Fence Collision Adjustment Factor. The final numeric value for each cell is the habitat services provided to greater sage-grouse by that cell.

The resulting habitat service values and the number of acres associated with each of the habitat service values were multiplied together and summed across the Assessment Area to calculate the total habitat services (expressed in service acres) (Equation 1). The total habitat services provided by the Assessment Area (those habitats within a 2-km buffer from the Project centerline and within BLM PGH) were calculated and serve as the baseline for the GWS Project.

Equation B.2.

$$VJ = \sum_{1}^{i} (V_i * J_{V_i})$$

where:

VJ is the habitat services (service-acres) provided by the Assessment Area;

V is the habitat service score (i.e., the sum of the variable scores in the habitat service metric);

i is the number of possible unique values for *V*; and

J_{V_i} is the number of acres for each value of V_i, where $\sum_{1}^{i} J_{V_i}$ would equal the total acreage of the Assessment Area (*J*).

B.5 Literature Cited

Stevens, B.S., D.E. Naugle, B. Dennis, J.W. Connelly, T. Griffiths, and K.P. Reese. 2013. Mapping sage-grouse fence-collision risk: Spatially-explicit models to target conservation implementation. *Wildlife Society Bulletin* 37(2):409–415.

APPENDIX C

Quantification of Habitat Service Losses

C. Quantification of Habitat Service Losses

Habitat service losses caused by the Gateway South Transmission Project (GWS Project) were modeled using geographic information system (GIS) technology for important GWS Project milestones by decreasing the variable scores for the habitat services metric below the baseline level in the footprint of the GWS Project (direct disturbances) and in buffers around the footprint (indirect disturbances). The habitat service scores for each milestone were summed across the Assessment Area to calculate the estimated interim and permanent habitat service losses associated with the GWS Project.

C.1 Description of Disturbances by GWS Project Milestone

The habitat services provided by the Assessment Area were measured at several different GWS Project milestones that reflected varying levels of disturbance.

The following GWS Project milestones were modeled for the habitat equivalency analysis (HEA).

Baseline—the baseline milestone quantifies habitat services available to greater sage-grouse (*Centrocercus urophasianus*) before disturbance. The calculation of the habitat services available to greater sage-grouse at baseline is described in Appendix B.

Construction—the transmission line construction milestone quantifies habitat services available to greater sage-grouse during the construction of the GWS Project.

Restoration—the restoration milestone quantifies habitat services available to greater sage-grouse after GWS Project construction is complete and some services return with the reduction in noise and human presence.

Recovery—there are four recovery milestones that quantify habitat services available to greater sage-grouse after a vegetation type has recovered to the greatest extent expected after GWS Project restoration is complete. Habitat services return to baseline conditions in restored areas with the time to recovery being dependent on the vegetation type. It is anticipated that there will be multiple vegetation-based recovery endpoints. Vegetation recovery endpoints will be determined upon identification of the vegetation communities impacted by the GWS Project.

C.2 Quantifying Loss of Habitat Services Due to Surface Disturbance during Construction

For the construction milestone, direct disturbances were defined as the loss of habitat services associated with vegetation removal and ground-disturbing activities within the construction footprint (Table C.1). The habitat service scores for all 30- by 30-meter (m) raster cells in the GWS Project footprint where vegetation removal or ground disturbance occur were changed from the baseline service scores to 0 in the GIS model for this milestone. Recovery from the disturbed state was applied per the vegetation-specific recovery curves for the GWS Project.

Table C.4. Direct Disturbance Levels Modeled by GWS Project Milestone and Disturbance Type

Project Milestones	Project Year Applied in Wyoming and Colorado	Project Year Applied in Utah	Percent Baseline Services Present at Each Milestone by Direct Disturbance Type		
			Series Compensation Stations	Transmission Towers* (360 feet^2 of the pad†)	New and Existing Access Roads, Helicopter Pads, Transmission Towers (remainder of pad), Pulling/Tensioning Site, and Elsewhere‡
Baseline	0	0	100%	100%	100%
Construction	1, 2	1, 2, 3	0%	0%	0%
Restoration	3	4	0%	0%	0%
Recovery 1	4	5	0%	0%	100% of agricultural and wetland 20% of grassland and riparian 5% of shrub 1% of sagebrush
Recovery 2	8	9	0%	0%	100% of agricultural and wetland 100% of grassland and riparian 25% of shrub 5% of sagebrush
Recovery 3	23	24	0%	0%	100% of agricultural and wetland 100% of grassland and riparian 100% of shrub 20% of sagebrush
Recovery 4	103	104	0%	0%	100% of agricultural and wetland 100% of grassland and riparian 100% of shrub 100% of sagebrush

* The self-supporting steel lattice tower is assumed for this analysis.
† Tower pad in this table refers to the permanent tower footprint.
‡ Elsewhere refers to construction roads that were reduced to two-track roads, or any areas where vegetation was cleared for Project construction that were subsequently revegetated during restoration (e.g., staging areas).

C.3 Quantifying Loss of Habitat Services Due to Indirect Disturbances during Construction

Indirect disturbances were simulated by applying buffers to the construction footprint and decreasing the habitat service scores below the baseline habitat service scores within the buffers. Because of uncertainties in the indirect impacts of transmission on greater sage-grouse, at this time, noise and human presence were the only indirect disturbance modeled in the HEA.

Use of construction equipment such as backhoes, cranes, front-end loaders, bulldozers, graders, excavators, compressors, generators, and various trucks would be needed for mobilizing crew, transportation and use of materials, line work, site clearing, and preparation during the construction phase of the GWS Project. Construction of and improvements to access roads would require use of earthmoving equipment such as bulldozers and graders. Table C.2 provides the typical noise levels for the construction equipment that could potentially be used during the construction phase of the GWS Project (ranging 80 to 90 A-weighted decibels [dBA] at 50 feet [15 m] from any work site) (Bureau of Land Management 2013).

Table C.5. Typical Noise Levels from Construction Equipment

Equipment Type	Noise Level at 50 feet (dBA)	Equipment Type	Noise Level at 50 feet (dBA)
Crane	88	Flatbed truck	88
Backhoe	85	Dump truck	88
Pan loader	87	Tractor	80
Bulldozer	89	Concrete truck	86
Fuel truck	88	Concrete pump	82
Water truck	88	Front end loader	83
Grader	85	Scraper	87
Roller	80	Air compressor	82
Mechanic truck	88	Average construction site	85

Noise during the construction phase of the GWS Project would be similar in magnitude to noise produced by vehicles using secondary roads (county highways, state highways, and heavily travelled gravel roads [e.g., access roads for oil and gas development, mining, etc.]). Passenger vehicles, medium trucks, and heavy trucks going 55 miles per hour produce typical noise levels of 72 to 74 dBA, 80 to 82 dBA, and 84 to 86 dBA, respectively, from a distance of 50 feet. Therefore, the noise disturbance associated with construction will be modeled as if the construction area was a secondary road (Table C.3).

In the model, buffers were placed around active construction areas in a manner that is identical to the methods used for secondary roads. The cells that fall within these buffers were scored in a manner identical to a secondary road (i.e., the score for VAR02 decreased).

Table C.6. Indirect Disturbance Levels Modeled by GWS Project Year and Disturbance Type

Project Milestones	Project Year Applied in Wyoming and Colorado	Project Year Applied in Utah	Indirect Disturbance Buffers* Applied by Disturbance Type		
			Series Compensation Stations	Transmission Towers* (360 feet^2 of the pad)	New and Existing Access Roads, Helicopter Pads, Transmission Lines, Transmission Towers (remainder of pad), and Pulling/Tensioning Site
Baseline	0	0	None	None	None
Construction	1, 2	1, 2, 3	Secondary Road*	Secondary Road	Secondary Road
Restoration	3	4	Secondary Road	None	None
Recovery 1	4	5	Secondary Road	None	None
Recovery 2	8	9	Secondary Road	None	None
Recovery 3	23	24	Secondary Road	None	None
Recovery 4	103	104	Secondary Road	None	None

* "Secondary Road" indicates that the footprint of the disturbance was classified as having the same indirect disturbance as a secondary road in the GIS model (Variable 2 in Table 1) and the scores of the surrounding vegetation decreased as defined by the habitat services metric.

C.4 Quantifying Habitat Services Losses During Restoration and Recovery

GWS Project-related habitat service losses are anticipated to decrease once construction is complete. Although still below baseline levels, the habitat service scores rise during restoration and recovery with vegetation regrowth (direct disturbances) and decreased levels of noise and human presence (indirect disturbances).

C.4.1 Restoration Milestone

For the restoration milestone, direct disturbances were defined as the loss of all habitat services in the construction footprint where vegetation clearing and ground disturbance occurs because the vegetation has not regrown sufficiently to provide habitat (Table C.1).

The indirect disturbance buffers that are applied to the series compensation stations during construction will remain during the restoration milestone and for the life of the GWS Project because of the noise and human activity associated with operation of the facility. No indirect disturbances were modeled for the rest of the GWS Project because little vehicle traffic or human presence is anticipated in these areas after construction of the line is complete.

C.4.2 Progressive Recovery Milestone

For the recovery milestone, direct disturbances were defined as the loss of all habitat services in a 360-square-foot footprint of the transmission structure pads and the partial loss of services in areas of vegetation regrowth (Table C.1). Indirect disturbances were applied in a manner identical to the construction milestone (Table C.3).

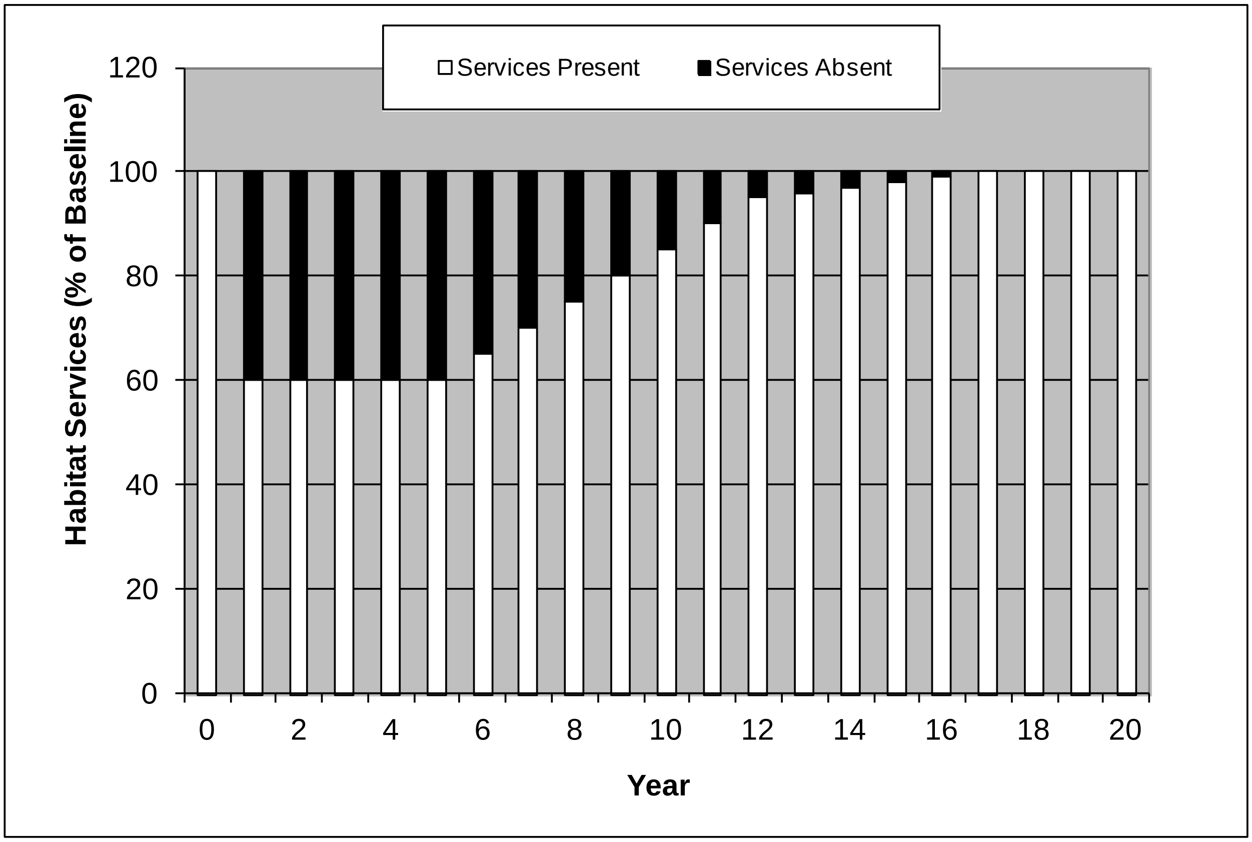
Habitat services in areas where the vegetation is reclaimed (i.e., outside the footprint of permanent facilities) will gradually return to baseline conditions at a rate dependent on the vegetation type. Services will return more rapidly for vegetation having rapid recovery rates (e.g., agriculture, wetland, grassland, or riparian) than for those with slower recovery times (e.g., shrub-dominated including sagebrush). Vegetation recovery curves were developed for the vegetation communities that are impacted by GWS Project activities.

To calculate the progressive return of services, the percentage of the baseline service value for a cell was calculated based on the appropriate vegetation recovery curve. For example, in those vegetation types with rapid restoration potential (agricultural areas, some grasslands, etc.), habitat services could be returned to 100% of baseline in the first year following construction. Those with longer recovery times may only achieve partial service returns per year until achieving their maximum value. For example, a vegetation community with a 50-year recovery period might achieve 10% value in year 5 after restoration, 20% in year 10, 30% in year 15, etc. until all services are returned in year 50.

C.4.3 HEA to Quantify Interim and Permanent Habitat Injuries

The approach described above produced a measure of habitat services (in service-acres) for each of the GWS Project milestones for each of the modeled project segments. The HEA is a stepwise model which quantifies the habitat injury separately in each year (Figure C.1). Each of the milestones was assigned to a calendar year. A linear change in habitat services was used to estimate annual service-acre increases between restoration and recovery and between the vegetation-specific recovery times.

The total number of service-acres lost per year was summed across the analysis period and expressed as service-acre-years. This value is the estimated sum of the interim and permanent losses to greater sage-grouse habitat that would occur as a result of the GWS project construction, operation, and maintenance.



Hypothetical example of how the HEA model considers habitat services absent and habitat services present in each year to calculate the total services lost over the Project period (i.e., sum of the black bars).

Figure C.1. HEA Model Calculation Example

The HEA model balances the cumulative injury (*I*, service-acre-years) over the lifetime of the GWS Project with the cumulative benefit of habitat restoration and mitigation (*R*, service-acre-years), so that the services returned by habitat restoration and mitigation are greater than or equal to the cumulative injury ($R \geq I$). The habitat injury (*I*, service-acre-years) was quantified for the life of the GWS Project using Equation 2. Equation 2 was adapted from Equation 8.1 in Allen et al. (2005). The discount rate (*r*) is anticipated to be set to 3%, which is standard for this type of analysis. The discount rate converts services being provided in different time periods into current time period equivalents (Allen et al. 2005). The discount rate effectively weighs the habitat service losses so that losses occurring early in the GWS Project result in a greater overall injury than losses occurring later in the project. Likewise, habitat restoration and mitigation occurring early in the GWS Project would result in a greater benefit than habitat restoration and mitigation occurring late in the project.

Equation C.3.

$$I = \sum_{t=1}^{y} (JV^{j} - JV^{t}) * \rho_{t}$$

where:

I is the present value of the service-acre-years lost over *y* due to interim and permanent injury;

t is the project year, with t= 1 being the year that GWS Project construction begins;

y is the analysis period, in years (e.g., 104);

JV^{j} is the value of the habitat services provided by the injured habitat (service-acres) before injury (i.e., at the Baseline milestone);

JV^{t} is the value of the habitat services provided by the injured habitat (service-acres) in year t; and

ρ_t is the discount factor, where $\rho_t = 1/(1+r)^{t-C}$, where *r* is the discount rate for the time period and *C* is the time the claim is presented (C = Project Year 1).

C.5 Literature Cited

Allen, P.D. II, D.J. Chapman, and D. Lane. 2005. Scaling environmental restoration to offset injury using habitat equivalency analysis. In *Economics and Ecological Risk Assessment: Applications to Watershed Management*, edited by R.F. Bruins and M.T. Heberling, pp. 165–184. Boca Raton, Florida: CRC Press.

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APPENDIX D

Quantification of Habitat Service Gains Produced by Habitat Restoration and Mitigation Measures

D. Modeling Mitigation Project Habitat Service Gains

Habitat restoration and conservation measures are intended to create new, or protect existing, greater sage-grouse (*Centrocercus urophasianus*) habitat services (Table D.1). These measures serve as a "toolbox" from which mitigation projects may be selected by Gateway South for inclusion in a mitigation package once the Bureau of Land Management has identified the preferred alternative and final habitat equivalency analysis (HEA) results are available for that alternative. The purpose of the mitigation projects is to offset the cumulative greater sage-grouse habitat service losses in the Assessment Area over the Gateway South Transmission Project (GWS Project) lifetime (i.e., I in Equation C.1). The HEA was used to evaluate the benefit of a sample of conservation measures in the Assessment Area.

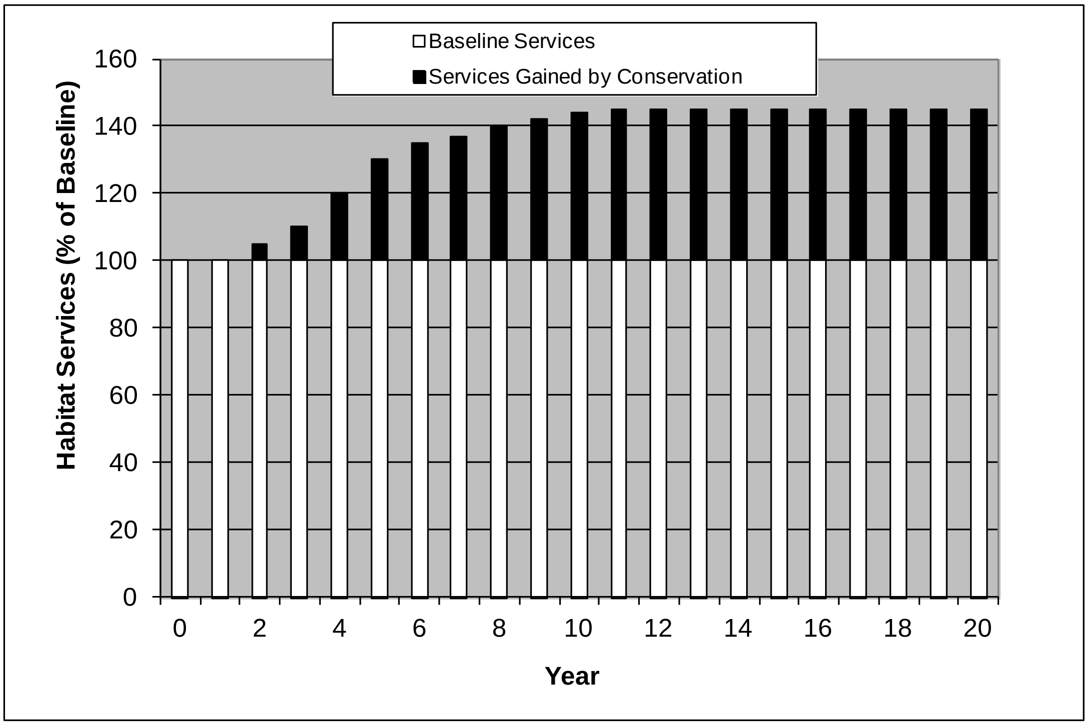
Table D.7. Potential Habitat Restoration and Conservation Measures for Inclusion in the HEA

Mitigation Project Type	Brief Project Description	Anticipated Benefits	Average Cost of Implementation*,§
Fence removal and marking with flight diverters	Fences would be removed or marked in: 1) sections of fence known to cause greater sage-grouse collisions; 2) within 3 km (1.2 miles) of leks (Stevens et al. 2013) or other high risk areas; 3) in areas with low slope and terrain ruggedness (Stevens 2011); and 4) where segments are bounded by steel t-posts with spans greater than 4 m (Stevens 2011).	• Reduce mortality due to greater sage-grouse collisions • Increase visibility of fences, where diverters are used • Increase contiguous patches of shrub-steppe habitat • Remove localized grazing pressure where fences are removed, thereby increasing local habitat quality (e.g., bunchgrass cover)	$1,485 per mile ($920 per km) for fence removal or initial installation of flight diverters, and $320 per mile per year ($200 per km per year) for maintenance on flight diverters†
Sagebrush restoration and improvement projects	Seeding, planting seedlings, or transplanting containerized sagebrush plants (one plant per 5 m^2)	• Create contiguous patches of shrub-steppe habitat with optimal sagebrush cover and height • Increase availability of high-quality nesting, brood rearing, and winter habitats	$3,975 to $7,320 per acre ($9,820 to $18,090 per hectare) depending on method used ^
Juniper/conifer removal	Mechanical removal (lop and scatter, cut-pile-cover, or mastication) of juniper/confer adjacent to areas with optimal sagebrush cover and height.	• Reverse juniper/conifer encroachment on shrub-steppe habitat to increase contiguous patches of greater sage-grouse habitat • Increase light penetration to support a forb and grass understory	$180 to $2,120 per acre ($445 to $5,240 per hectare) depending on density of vegetation removed ‡
Conservation easements	Removes threat of specific land uses to sensitive wildlife populations.	• Prevent greater sage-grouse habitat destruction or degradation near urban areas and oil and gas development • Reduce future fragmentation of shrub-steppe habitat	$615 per acre ($1,515 per hectare) average purchase price $2,650 per year for each easement for maintenance and monitoring

* Cost of implementation includes a 50% markup for indirect costs, which include contract writing, supervision, clearances, monitoring, inspections, and vehicle costs.
† The cost of maintenance for the lifetime of the Project is included in the HEA model and the resulting estimated cost per service-acre-year.
‡ The cost of this treatment varies widely depending on the baseline vegetation. The lower end cost includes lop and scatter of Phase I juniper with no understory treatment. The upper end cost includes mastication of Phase III juniper and seeding a bunchgrass understory.
§ Costs were estimated for the Gateway West Transmission Line HEA (BLM 2013) and then adjusted using a 3% inflation rate to bring them up to 2014 dollars. Mitigation funds provided in years after 2014 should be further adjusted for inflation.
^ Cost estimates include seeding a bunchgrass understory, although the benefit of a bunchgrass understory could not be measured by the HEA metric.
km = kilometer m = meter

D.1 GIS Modeling of Conservation Benefits

The analysis of habitat service benefits produced by each habitat restoration or mitigation measure in Table D.1 was completed using an approach similar to that described for quantifying habitat losses. It is necessary that both analyses (i.e., quantification of habitat service losses and habitat service gains) use the same habitat services metric (see Appendix A), the same unit of measure (service-acres and service-acre-years), the same analysis period, and the same discount rate. Figure D.1 illustrates a hypothetical example of how mitigation was added to the baseline service metric over time to derive an estimate of the service-acre-years provided by the mitigation measures that were modeled for the GWS Project.



Hypothetical example of how the HEA model considers habitat services gained by habitat restoration and mitigation to calculate the total services gained over the project period (i.e., sum of the black bars).

Figure D.2. HEA services gained example

D.1.1 Modeling Habitat Restoration and Mitigation Measures

Hypothetical habitat restoration and mitigation project areas were used to estimate average habitat service gain. Once beneficial locations for these projects were identified, variable scores in the HEA model were changed to approximate the change in habitat services expected with implementation of the measure (Table D.2). The new habitat service score was calculated for each cell in the Assessment Area using the same habitat services metric used to quantify baseline and impacts (see Appendix A). The habitat service benefit of a modeled mitigation project was calculated by determining the difference in the habitat services provided at baseline and after implementation of the habitat restoration or mitigation measure. For each habitat restoration/mitigation project type, the assumed time to full benefit and project initiation timing are provided in Table D.3. A linear increase in services was assumed between project initiation and time of full benefit.

Table D.8. Site Selection and Changes in Metric Scoring Applied During GIS Analysis of Conservation Measure Benefit

Type of Improvement	Site Selection Criteria	Changes in Metric Scoring	Analysis Product
Fence removal and marking with reflectors	Priority areas for fence removal and/or marking are as follows: 1) sections of fence known to cause greater sage-grouse collisions; 2) within 2 km (1.2 miles) of leks (Stevens et al. 2013) or other high risk areas; 3) in areas with low slope and terrain ruggedness (Stevens 2011); and where segments are bounded by steel t-posts with spans greater than 4 m (Stevens 2011).	Remove fence score adjustment for a known length of high priority fences in the analysis area*	Analysis provided the services gained, the analysis area, and the kilometers of fences marked and removed in the analysis area.
Sagebrush restoration and improvement projects	Smaller patches of agriculture or surface disturbance (i.e., well pads) surrounded by sagebrush habitat.	• Make it a modeled habitat type • Change Sagebrush Abundance Index score as appropriate • Change Sagebrush Canopy Cover score to 3 • Change the Sagebrush Canopy Height to 3 • Change the scores of the surrounding cells for Distance of Habitat to Sage or Shrub Dominant	Analysis provided the services gained, the area of the analysis, and the area of the habitat improvement (i.e., the agricultural field or well pad)
Juniper/conifer removal	Phase I Juniper (a sagebrush-dominated landscape with scattered juniper) adjacent to sagebrush	• Make it a modeled habitat type • Change Sagebrush Abundance Index score as appropriate • Change Sagebrush Canopy Cover score to average score of local sagebrush vegetation • Change the Sagebrush Canopy Height score to average score of local sagebrush vegetation • Change the scores of the surrounding cells for Distance of Habitat to Sage or Shrub Dominant	Analysis provided the services gained, the total analysis area, and the acres of juniper removed.

Type of Improvement	Site Selection Criteria	Changes in Metric Scoring	Analysis Product
	Phase II Juniper (50:50 mix sagebrush and juniper) adjacent to sagebrush	• Make it a modeled habitat type • Change Sagebrush Abundance Index score as appropriate • Change Sagebrush Canopy Cover score to average score of local sagebrush vegetation • Change the Sagebrush Canopy Height score to average score of local sagebrush vegetation • Change the scores of the surrounding cells for Distance of Habitat to Sage or Shrub Dominant	Analysis provided the services gained, the total analysis area, and the acres of juniper removed.
	Phase III Juniper (a juniper-dominated landscape) adjacent to sagebrush	• Make it a modeled habitat type • Change Sagebrush Abundance Index score as appropriate • Change Sagebrush Canopy Cover score to average score of local sagebrush vegetation • Change the Sagebrush Canopy Height score to average score of local sagebrush vegetation • Change the scores of the surrounding cells for Distance of Habitat to Sage or Shrub Dominant	Analysis provided the services gained, the total analysis area, and the acres of juniper removed.
Conservation easements	Areas with average habitat service scores within sage-grouse priority general habitat (PGH)	No change to metric score. Calculate average habitat service score within PGH at baseline.	Analysis provided the average baseline services per acre present in PGH in the analysis area

* Although fence removal is more effective at removing the threat of sage-grouse collision than fence marking, both measures were modeled the same for the HEA

Table D.9. Time to Project Implementation and Time to Full Benefit of Project Used in HEAs of Conservation Measures

Type of Improvement	Year of Implementation Assuming Funding at Project Initiation	Time to Full Benefit of Project After Implementation
Fence removal and marking with reflectors	Year 1	Immediate full benefit
Sagebrush restoration and improvement projects	Year 3	Seeding sagebrush and bunchgrass understory: 100 years to full benefit (assume linear increase in services)*
	Year 5	Transplanting containerized stems and seeding bunchgrass understory: 15 years to full benefit (assume linear increase in services)
	Year 3	Planting seedlings and seeding bunchgrass understory: 90 years to full benefit (assume linear increase in services)
Juniper/conifer removal	Year 3	Lop and Scatter Phase I Juniper: 20 years to full benefit (assume linear increase in services)
	Year 3	Cut-Pile-Cover or Mastication of Phase II Juniper: 50 years to full benefit (assume linear increase in services)
	Year 3	Mastication of Phase III Juniper plus bunchgrass seeding: 100 years to full benefit (assume linear increase in services)
Conservation easements	Year 2	Immediate full benefit once established

* Time to sagebrush establishment is based on passive restoration rates. Rates of establishment are expected to be higher for this active restoration, but the longer time is used in the analysis to offset potential restoration project failures.

The present value habitat service gain (*R*, service-acre-years) was quantified for the life of the GWS Project using Equation D.1 (adapted from Equation 8.1 in Allen et al. 2005).

Equation D.4.

$$R = \sum_{t=1}^{y} (PV^{t} - PV^{p}) * \rho_{t}$$

where:

R is the present value of the service-acre-years gained by the habitat restoration or mitigation measure;

$t = 1$ is the year the transmission line GWS Project begins;

y is the analysis period, in years (i.e., 104);

PV^p is the value of the habitat services provided by the improved habitat (service-acres) before habitat restoration or mitigation measure (i.e., at the Baseline milestone);

PV^t is the value of the habitat services provided by the improved habitat (service-acres) in year *t*; and

ρ_t is the discount factor, where $\rho_t = 1/(1+r)^{t-C}$, where *r* is the discount rate for the time period and *C* is the time the claim is presented (*C* = Project Year 1).

The present value habitat service gain (*R*) was standardized among mitigation project types by dividing by size of mitigation project (units in acres or linear mile depending on the conservation measure modeled) and averaged among hypothetical projects applying the same conservation measure to produce the service-years gained per unit of treatment ($\overline{R}^m$). This value was used in mitigation calculations.

D.2 Estimating Cost to Implement Modeled Habitat Restoration and Mitigation Measures

The cost of the modeled habitat conservation measures was estimated by adjusting the cost estimates from the Gateway West HEA by 3% annually from 2012 to 2014 to account for inflation. The Gateway West HEA averaged the known cost of similar mitigation projects previously implemented (in current year U.S. dollars). The cost per unit treated was divided by the average service-acre-years gained per unit area treated (calculated for the GWS Project in the previous section), to estimate the price per service-acre-year gained for each of the habitat restoration and mitigation measures. This is the currency that will be used to offset the permanent and interim habitat service losses associated with the GWS Project's construction, operation, and maintenance for the lifetime of the GWS Project.

D.3 Approach to Offset Habitat Service Losses with Habitat Service Gains

An HEA scales the mitigation package (i.e., funding to create habitat services) to offset the loss of habitat services over the lifetime of the GWS Project. The injury is offset by planned habitat restoration and mitigation projects in Equation D.2, where the mitigation project size (P^m) can be solved for each habitat restoration or mitigation measure type (m).

Equation D.5.

$$I = \sum_{m1}^{i} P^m * \overline{R}^m$$

where:

I is the present value of the service-acre-years lost over y due to interim and permanent injury;

i is the number of habitat restoration and mitigation measures modeled;

Pm is the size of the habitat restoration or mitigation project of type m (in units of acres or miles); and

$\overline{R}^m$ is mean service-years gained per unit (acres or miles) of treatment.

Once the P^m is defined for each habitat improvement and mitigation measure, the costs per unit can be applied. Mitigation due is the sum of the costs to implement each of the habitat improvement and mitigation projects needed to offset the GWS Project.

D.4 Literature Cited

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APPENDIX E

Assignment of National Gap Analysis Program (GAP) Vegetation Classifications to Categories for HEA Modeling

E. Vegetation Categorization for HEA Modeling

Vegetation and other landcover types in the U.S. Geological Survey national Gap Analysis Program (GAP) Land Cover Dataset were classified as providing habitat for greater sage-grouse (*Centrocercus urophasianus*) or not providing habitat for greater sage-grouse. Vegetation types providing no habitat services to greater sage-grouse (Non-Habitat in Table E.1) were assumed to require no mitigation in the habitat equivalency analysis (HEA). Those vegetation types that are used by greater sage-grouse (Table E.1) were assigned to one of four modeled vegetation categories. Each of the modeled vegetation categories had a different vegetation recovery time in the HEA model.

Table E.10. Vegetation Categorization Based on GAP Landcover Types

Vegetation Categories	GAP Vegetation: ECOLSYS_LU
Non-Habitat: Anthropogenic Disturbance and Open Water	Developed, High Intensity
	Developed, Low Intensity
	Developed, Medium Intensity
	Developed, Open Space
	Disturbed/Successional - Recently Chained Pinyon-Juniper
	Open Water (Fresh)
	Quarries, Mines, Gravel Pits and Oil Wells
Non-Habitat: Natural Vegetation	Colorado Plateau Mixed Bedrock Canyon and Tableland
	Colorado Plateau Pinyon-Juniper Shrubland
	Colorado Plateau Pinyon-Juniper Woodland
	Great Basin Pinyon-Juniper Woodland
	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland
	Inter-Mountain Basins Cliff and Canyon
	Inter-Mountain Basins Juniper Savanna
	Inter-Mountain Basins Shale Badland
	Introduced Riparian and Wetland Vegetation
	Introduced Upland Vegetation - Annual Grassland
	Introduced Upland Vegetation - Perennial Grassland and Forbland
	Introduced Upland Vegetation - Treed
	North American Warm Desert Bedrock Cliff and Outcrop
	North American Warm Desert Lower Montane Riparian Woodland and Shrubland
	Recently Burned
	Rocky Mountain Alpine Bedrock and Scree
	Rocky Mountain Aspen Forest and Woodland
	Rocky Mountain Bigtooth Maple Ravine Woodland
	Rocky Mountain Cliff, Canyon and Massive Bedrock
	Rocky Mountain Foothill Limber Pine-Juniper Woodland

Vegetation Categories	GAP Vegetation: ECOLSYS_LU
	Rocky Mountain Gambel Oak-Mixed Montane Shrubland
	Rocky Mountain Lodgepole Pine Forest
	Rocky Mountain Lower Montane Riparian Woodland and Shrubland
	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland
	Southern Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland
	Western Great Plains Cliff and Outcrop
Habitat: Agriculture and Wetland (HEA assumed 1 year recovery time)	Cultivated Cropland
	Inter-Mountain Basins Playa
	North American Arid West Emergent Marsh
	North American Warm Desert Playa
	Pasture/Hay
	Rocky Mountain Alpine-Montane Wet Meadow
	Rocky Mountain Subalpine-Montane Mesic Meadow
	Western Great Plains Closed Depression Wetland
	Western Great Plains Open Freshwater Depression Wetland
	Western Great Plains Saline Depression Wetland
Habitat: Grassland and Riparian (HEA assumed 5 years recovery time)	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
	Inter-Mountain Basins Semi-Desert Grassland
	North American Warm Desert Riparian Mesquite Bosque
	North American Warm Desert Wash
	Northwestern Great Plains Mixedgrass Prairie
	Rocky Mountain Subalpine-Montane Riparian Shrubland
	Southern Rocky Mountain Montane-Subalpine Grassland
	Western Great Plains Riparian Woodland and Shrubland
Habitat: Sagebrush (HEA assumed 20 years recovery time)	Colorado Plateau Mixed Low Sagebrush Shrubland
	Great Basin Xeric Mixed Sagebrush Shrubland
	Inter-Mountain Basins Big Sagebrush Shrubland
	Inter-Mountain Basins Big Sagebrush Steppe
	Inter-Mountain Basins Montane Sagebrush Steppe
Habitat: Shrub Steppe (HEA assumed 100 years recovery time)	Great Basin Semi-Desert Chaparral
	Inter-Mountain Basins Active and Stabilized Dune

Vegetation Categories	GAP Vegetation: ECOLSYS_LU
	Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland
	Inter-Mountain Basins Greasewood Flat
	Inter-Mountain Basins Mat Saltbush Shrubland
	Inter-Mountain Basins Mixed Salt Desert Scrub
	Inter-Mountain Basins Semi-Desert Shrub Steppe
	Mogollon Chaparral
	Mojave Mid-Elevation Mixed Desert Scrub
	Rocky Mountain Lower Montane-Foothill Shrubland
	Sonora-Mojave Creosotebush-White Bursage Desert Scrub
	Sonora-Mojave Mixed Salt Desert Scrub
	Wyoming Basins Dwarf Sagebrush Shrubland and Steppe

APPENDIX F

Specific Conservation Objectives and Measures Identified in the Conservation Objectives Report (COR)

F. Specific Conservation Objectives and Measures Identified in the Conservation Objectives Report

In February 2013, the U.S. Fish and Wildlife Service (USFWS) issued a Conservation Objectives Report (COR) (USFWS 2013) that details the finding of a Conservation Objectives Team (COT) that was convened and asked to develop and recommend the degree and types of threats that would need to reduced or eliminated in order to conserve the greater sage-grouse (*Centrocercus urophasianus*) from being in danger of extinction and to prevent the likeliness of the sage-grouse becoming in danger of extinction in the foreseeable future. The specific conservation objectives and measures identified in the Conservation Objectives Report (COR) are provided in the following sections.

F.1 Priority Areas for Conservation

Priority areas for conservation (PACs) are key areas (not populations) across the landscapes that are necessary to maintain redundant, representative, and resilient populations. The PACs were developed by identifying key areas across the landscape that is necessary to maintain redundant, representative, and resilient populations. Existing mapping that state's had already gathered concerning the location of sage-grouse habitat was used to identify the areas that would be needed to maintain sage-grouse representation, redundancy, and resilience across the landscape. This mapping, in general, used lek counts, telemetry, nesting areas, known distribution, sightings/observations, and habitat distribution to identify their respective PACs.

Maintenance of the integrity of PACs is the essential foundation for sage-grouse conservation. Incorporation of objectives into conservation planning efforts, including rigorous monitoring plans, will help provide the assurance that the long-term population trend objectives are likely to be attained.

Conservation of sage-grouse habitats outside of PACs are important as they provide connectivity between PACs and should include minimization of impacts to sage-grouse and healthy native plant communities. If minimization is not possible due to valid existing rights, mitigation for impacted habitats should occur.

The following objectives are targeted at conserving PACs, but can be applied to sage-grouse habitats outside of PACs. These objectives apply to both the Bi-State distinct population segments (DPS) and sage-grouse range-wide. Achieving these objectives will conserve redundancy and representation of the species and its habitats across its range.

1. Retain sage-grouse habitats within PACs.
2. If PACs are lost to catastrophic events, implement appropriate restoration efforts.
3. Restore and rehabilitate degraded sage-grouse habitats in PACs.
4. Identify areas and habitats outside of PACs which may be necessary to maintain the viability of sage-grouse.
5. Re-evaluate the status of PACs and adjacent sage-grouse habitat at least once every 5 years, or when important new information becomes available.
6. Actively pursue opportunities to increase occupancy and connectivity between PACs.
7. Maintain or improve existing habitat conditions in areas adjacent to burned habitat. In the late summer of 2012, several large wildfires in the Great Basin burned through sage-grouse habitats, including PACs.

F.2 Identifying Sage-Grouse Population Threats

The following 14 sage-grouse and sage-grouse habitat threats are identified in the COR.

1. Fire
2. Non-native, Invasive Plant Species
3. Energy Development
4. Sagebrush Removal
5. Grazing
6. Range Management Structures
7. Free-Roaming Equid Management
8. Pinyon-Juniper Expansion
9. Agricultural Conversion
10. Mining
11. Recreation
12. Ex-Urban Development
13. Infrastructure
14. Fences

A discussion of each threat, including the conservation objectives, measures, and options, is provided below.

1. Fire

Conservation Objective

Retain and restore healthy native sagebrush plant communities within the range of sage-grouse by replacing the invasive annuals with native perennial bunchgrass communities both within and outside of PACs.

Conservation Measures

1. Restrict or contain fire within the normal range of fire activity.
2. Eliminate intentional fires in sagebrush habitats.
3. Design and implement restoration of burned sagebrush habitats to allow for natural succession to healthy native sagebrush plant communities that result in returning or increasing sage-grouse populations within the burned areas.
4. Implement monitoring programs for restoration activities and their completeness.
5. Immediately suppress fire in all sagebrush habitats.

Conservation Options

1. Prevention of fires in sage-grouse habitats.
2. Quickly suppress fires that do occur.
3. Improve restoration support.
4. Renew and implement Bureau of Land Management (BLM) Instructional Memorandum (IM) 2011-138 (Sage-grouse Conservation Related to Wildland Fire and Fuels Management; BLM 2011) until a decision is made on whether to incorporate the measures identified in the IM into Resource Management Plans.

2. Non-native, Invasive Plant Species

Conservation Objective

Maintain and restore healthy, native sagebrush plant communities.

Conservation Measures

1. Retain all remaining large intact sagebrush patches particularly at low elevations.
2. Reduce or eliminate disturbances that promote the spread of these invasive species.
3. Monitor and control invasive vegetation post-wildfire for at least 3 years.
4. Require best management practices for construction projects in and adjacent to sagebrush habitats to prevent invasion.
5. Restore altered ecosystems so that non-native invasive plants are reduced to levels that do not put the area at risk of conversion if a catastrophic event were to occur.

3. Energy Development

Conservation Objective

Energy development should be designed to ensure that it will not impinge upon stable or increasing sage-grouse population trends.

Where state sage-grouse management plans have already identified an effective strategy for energy development that meets the above objective, the strategies in those plans should be implemented. In all other situations, the following measures should be considered to avoid, reduce, or mitigate impacts from energy development.

Conservation Measures

1. Avoid energy development in PACs.
2. If avoidance is not possible within PACs, development should only occur in non-habitat areas.
3. If development must occur in sage-grouse habitats the development should occur in the least suitable habitat for sage-grouse and be designed to ensure that there are no detectable declines in population trends by using the following.
    a. Reduce and maintain the density of energy structures below which there are not impacts to the function of the sage-grouse habitats or do not result in declines in sage-grouse populations within PACs.
    b. Design development outside PACs.
    c. Consolidate structures and infrastructure associated with energy development.
    d. Reclamation of disturbance resulting from a proposed project should only be considered as mitigation for those impacts.
    e. Design development to minimize tall structures or other features associated with the development.

4. Sagebrush Removal

Conservation Objective

Avoid sagebrush removal or manipulation in sage-grouse breeding or wintering habitats. Exceptions to this can be considered where minor habitat losses are sustained while implementing other habitat improvement or maintenance efforts (e.g., juniper removal) and in areas used as late summer brood habitat.

5. Grazing

Conservation Objective

Conduct grazing management for all ungulates that is consistent with the local ecological conditions that maintains or restores healthy sagebrush shrub and native perennial grass and forb communities and/or conserves the essential habitat components for sage-grouse. Areas which do not currently meet this standard should be managed to restore these components. In addition, adequate monitoring of grazing strategies and their results is essential to ensuring that desired results are achieved.

Achieving the above objective will require the development of long-term strategies that provide seasonal habitats for sage-grouse. Although grazing management should initially focus on retaining the above habitat conditions within PACs, sound grazing management should be applied across all sagebrush habitats. There are several potentially useful tools for developing management strategy metrics, such as Ecological Site Descriptions (ESDs) and Proper Functioning Conditions (PFC) for riparian areas, or Rangeland Health Standards (RHS) for uplands. However, use of these tools must be tied to sage-grouse habitat and population parameters if they are to be considered as a sole measure for monitoring condition and, if appropriate, rehabilitation progress.

Conservation Options

1. Ensure that allotments meet ecological potential and wildlife habitat requirements and ensure that the native perennial grass community is consistent with the ecological site.
2. Inform and educate affected grazing permittees regarding sage-grouse habitat needs and conservation measures.
3. Incorporate sage-grouse habitat needs or habitat characteristics into relevant resource and allotment management plans
4. Conduct habitat assessments and determine factors causing any failure to achieve the habitat characteristics.
5. Priority should be given to PACs and then sage-grouse habitats adjacent to PACs.

6. Range Management Structures

Conservation Objective

Avoid or reduce the impact of range management structures on sage-grouse. Typical range management structures include fences, water developments, and mineral licks.

Conservation Measures

1. Range management structures should be designed and placed to be neutral or beneficial to sage-grouse.
2. Structures that are currently contributing to negative impacts to either sage-grouse or their habitats should be removed or modified.

7. Free-Roaming Equid Management

Conservation Objective

Protect sage-grouse from the negative influences of grazing by free-roaming equids.

Conservation Measures

1. Develop, implement, and enforce adequate regulatory mechanisms to protect sage-grouse.
2. Manage free-roaming equids at levels that allow native sagebrush vegetative communities to minimally achieve PFC (for riparian areas) or RHS (for uplands).

Conservation Options

1. Determine if the current appropriate management levels maintain suitable sage-grouse habitat parameters and support additional research to quantitatively determine impacts of wild horses and burros on sage-grouse habitat parameters.
2. Until research is completed, manage for appropriate management levels within horse management areas on federal lands.
3. Develop scientific procedures that can be replicated to count horses.
4. Develop a sound monitoring program with prescriptive management indicators to make adjustments in horse and burro numbers or their distribution.

8. Pinyon-Juniper Expansion

Conservation Objective

Remove pinyon-juniper from areas of sagebrush that are most likely to support sage-grouse (post-removal) at a rate that is at least equal to the rate of pinyon-juniper incursion. Pinyon and/or juniper removal activities should focus initially on areas within PACs, but all opportunities to remove this threat should be considered if resources are available.

Conservation Options

1. Prioritize the use of mechanical treatments for removing pinyon and/or juniper.
2. Use caution when planning use of prescribed fire in high-elevation mountain big sage sites to prevent fire escape and any subsequent establishment of invasive annual grasses or other weeds.
3. Reduce juniper cover in sage-grouse habitats to less than 5%.
4. Employ all necessary management actions to maintain the benefit of pinyon and/or juniper removal for sage-grouse habitats.

9. Agricultural Conversion

Conservation Objective

Avoid further loss of sagebrush habitat for agricultural activities and prioritize restoration. In areas where taking agricultural lands out of production has benefited sage-grouse, the programs supporting these actions should be targeted and continued. Threat amelioration activities should be prioritized within PACs but should also be considered in all sage-grouse habitats.

Conservation Options

1. Revise Farm Bill policies and commodity programs that facilitate ongoing conversion of native habitats to marginal croplands to support conservation of remaining sagebrush-steppe habitats.
2. Continue and expand incentive programs that encourage the maintenance of sagebrush habitats.
3. Develop criteria for set-aside programs which stop negative habitat impacts and promote the quality and quantity sage-grouse habitat.
4. If lands that provide seasonal habitats for sage-grouse are taken out of a voluntary program precautions should be taken to ensure withdrawal of the lands that minimize the risk of direct take of sage-grouse.

10. Mining

Conservation Objective

Maintain stable to increasing sage-grouse populations and no net loss of sage-grouse habitats in areas affected by mining. Reclamation of mined lands within sage-grouse habitats should be focused on restoring habitats usable by sage-grouse, and the re-establishment of sage-grouse in these areas.

Conservation Options

1. Avoid new mining activities and/or any associated facilities within occupied habitats.
2. Avoid leasing in sage-grouse habitats until other suitable habitats can be restored.
3. Reclamation plans should focus on restoring areas disturbed by mining and associated facilities to healthy sagebrush ecosystems.
4. Reclamation of abandoned mine lands should focus on restoring areas to healthy sagebrush ecosystems.

11. Recreation

Conservation Objective

In areas subjected to recreational activities, maintain healthy native sagebrush communities based on local ecological conditions and with consideration of drought conditions and manage direct and indirect human disturbance (including noise) to avoid interruption of normal sage-grouse behavior. Threat amelioration for recreation should be implemented in PACs and considered in all other sage-grouse habitats.

Conservation Options

1. Close important sage-grouse use areas to off-road vehicle use.
2. Avoid development of recreational facilities in sage-grouse habitats.

12. Ex-Urban Development

Conservation Objective

Limit urban and exurban (disperse home on small acreages) development in sage-grouse habitats and maintain intact native sagebrush plant communities. At a minimum, threat amelioration for ex-urban development should occur within PACs and should also be considered in all sage-grouse habitats. In all other situations the following conservation options should be considered.

Conservation Options

1. Provide incentives to maintaining large tracts of private lands that provide habitat for sage-grouse. These incentives can include developing habitat conservation plans; conservation easements or leases; and/or land swaps.
2. Acquire and manage sage-grouse habitat to maintain intact ecosystems.
3. Consolidate infrastructure that supports urban and ex-urban development.
4. Do not allow landfills within sage-grouse habitats or within 5 kilometers of sage-grouse habitats.
5. Do not relinquish public lands for the purpose of urban development in sage-grouse habitat.

13. Infrastructure

Conservation Objective

Avoid development of infrastructure (roads, pipelines, power lines, cellular towers, etc.) within PACs.

Conservation Measures

There should be no new development of infrastructure corridors within PACs. Designated, but not yet developed infrastructure corridors should be re-located outside of PACs unless it can be demonstrated that these corridors will have no impacts on the maintenance of neutral or positive sage-grouse population trends and habitats.

Conservation Options

1. Avoid construction in sage-grouse habitat.
2. Power transmission corridors which cannot avoid PACs should be buried (if technically feasible) and disturbed habitat should be restored and/or preclude development of new structures within locally important sage-grouse habitats. If avoidance is not possible and consolidate new structures with existing features keeping corridors to 200 meters in width or less. Habitat function lost from placement of infrastructure should be replaced.
3. Infrastructure corridors should be designed and maintained to preclude introduction of invasive plant species.
4. Restrictions limiting use of roads should be enforced.
5. Remove transmission lines and roads that are duplicative or are not functional.
6. Transmission line towers should be constructed to severely reduce or eliminate nesting and perching by avian predators.
7. Avoid installation of compressor stations in sage-grouse habitats where the sage-grouse would be affected by noise and operation activities.
8. All commercial pipelines should be buried and habitat that is disturbed needs to be reclaimed with emphasis placed on suppression of non-native invasive plant species.
9. Mitigate impacts to habitat from development of these features.
10. Remove (or decommission) non-designated roads within sagebrush habitats.

14. Fences

Conservation Objective

Minimize the impact of fences on sage-grouse populations.

Conservation Options

1. Mark fences that are in high risk areas for collision with permanent flagging or other suitable device to reduce sage-grouse collisions located within 2 kilometers of occupied leks.
2. Identify and remove unnecessary fences.
3. Placement of new fences and livestock management facilities should consider their impact on sage-grouse and be placed at least 1 kilometer from occupied leks.

F.3 Literature Cited

U.S. Fish and Wildlife Service (USFWS). 2013. *Greater Sage-grouse (*Centrocercus urophasianus*) Conservation Objectives: Final Report*. U.S. Fish and Wildlife Service, Denver, CO. February 2013.